

IMPACT OF INSECTICIDE RESISTANCE ON CONTROL OF *Aedes aegypti*

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Abstract The biological characterization of resistance in laboratory is reported, along with an evaluation of the response of vector populations to methods of chemical control which are used on the routine executed in the Dengue Control. Data from the Monitoring Program demonstrated over time an increasing number of resistant populations to the main larvicide used (temephos), that adult resistance to the pyrethroid class is spread across the state since 2000 and that there is a decreased field control in resistant populations. There is evidence that the development of insecticide resistance has been influenced by intensive control of epidemics since this was more pronounced in populations of *Aedes aegypti* from the regions with the highest cumulative incidence of the disease. We conclude that there is a general trend of loss of susceptibility to products used for the control of *Aedes aegypti*. The management strategies were not enough, so far, to reverse resistance. Control actions in the field were less effective in populations characterized as “Resistant” in laboratory evaluation, indicating that resistance management must be adopted when insect populations are in the “reduced susceptibility” status. The use of insecticides is a self-limited tool that must be preserved and dengue control should be based on more sustainable strategies.

Key Words Insecticide resistance

INTRODUCTION

Currently the only way of controlling dengue is through vector control, since vaccines are not available yet (Gubler, 1989). Among the forms of vector control, chemical control with insecticides is an important tool to interrupt transmission of the disease and its effectiveness depends, besides the operational issues, on the insect susceptibility insecticides.

There are reports in Brazil of *Aedes aegypti* resistance to the most used insecticides (Braga et al. 2004; Lima et al., 2003; Macoris et al., 1995, 1999, 2003; Cunha et al., 2005). There is a unique experience in the state of Sao Paulo where monitoring resistance of different populations of *Aedes aegypti* has been done since 1996. The analysis of the evolution of vector resistance to insecticides in the state of São Paulo, as well as the response of populations to the doses used in the field may contribute to the understanding of the process of resistance development, assess the impact of resistance in control operations and support the choice of management strategies for a more effective vector control.

MATERIALS AND METHODS

Data from the monitoring program of the susceptibility of *Aedes aegypti* to insecticides were evaluated for vector populations from the state of São Paulo. Some municipalities are considered as sentinels for their respective regions. It is understood that the sampled population (sentinel) represents the susceptibility profile of the vector populations in the region (Braga and Valle, 2007).

The monitoring program consists of three steps: characterization of susceptibility, identification of resistance mechanisms and evaluating the impact of resistance in routine chemical treatments. This study analyzed the historic of biological characterization of susceptibility and data from the evaluation of biological response in a situation of pesticide use in the technique used in routine field control. Characterization of susceptibility is

evaluated in bioassays using the standard protocols by the World Health Organization - WHO / WHO. For larvae were analyzed data from qualitative tests using a diagnostic dose (Organization Mundial de la Salud, 1960, WHO 1981 a, b, 1992, 1998) and from quantitative dose-with the estimation of resistance ratio (RR) (WHO 1981c, 2000; Macoris et al., 2007). For adult insects were analyzed data from qualitative assays with diagnostic dose with impregnated papers (WHO 1981 a,b, c, 1992, 1998). The criteria for interpretation of diagnostic dose bioassays are the ones recommended by the World Health Organization (WHO, 1998), where the mortality rate of more than 98% characterizes the population "Susceptible", less than 80% characterizes it as "Resistant" and values between 80 and 98% characterize the population with "Reduced Susceptibility".

The evaluation of the effectiveness of treatment with insecticides in simulated field conditions to assess the impact of resistance detected in the laboratory in routine treatment, are made with commercial products and application techniques used in the Control Program - treatment, focal and perifocal space. To evaluate the efficacy of focal treatment were analyzed data from tests to evaluate the residual effect of larvicides according to methodology recommended by WHO (2005), while for perifocal treatment evaluation was made on data from wall tests (WHO 1996; 2006) and for evaluation of spatial treatment, data from bioassays with sentinel cages (Rezende et al., 1998; WHO 2001, 2003).

Data Analysis

The Network MoReNAa uses as a criterion indicating the replacement of larvicide when Resistance Ratio is equal to or greater than 3 at the level of 95% lethal concentration. (Secretaria de Vigilância em Saúde, 2006). For field efficacy tests it is considered a satisfactory mortality rates exceeding 80% (WHO 1982, 1996, 2005, 2006). The criterion of interpretation also adds the response compared with the reference susceptible strain (Rockefeller), a percentage lower than 70% of the response of the sensitive strain is suggestive of indicating replacement of the evaluated product (Secretaria de Vigilância em Saúde, 2004).

RESULTS AND DISCUSSION

Although it was observed a general trend of evolution for resistance to products used for its control, there was differentiation among populations of *Aedes aegypti* analyzed. It was registered a decreased response in the field control in mosquito populations that presented Resistance Ratio of 3 at lethal concentration 95% for the larvicide temephos. For the adults there was lack of effectiveness in the field for all populations of *Aedes aegypti* characterized as resistant to pyrethroids in laboratory. The management strategy with substitution of insecticides in areas with resistance and restriction of chemical control in the state as a whole started from 2001 and until the present date was not sufficient to reverse the resistance detected, nor prevent the development of resistance in other regions.

CONCLUSIONS

The results indicated a general trend toward loss of susceptibility to products used for the control of *Aedes aegypti*. The cut-off level indicative for resistance management of larvicide resistance is sensitive to detect possibility of field failure. The characterization of resistance of adults in qualitative assays in laboratory was accompanied in most populations studied by control failure in the field. The management strategies used, with substitution of products in areas of resistant populations were not enough, so far, to reverse the resistance detected. The strategy of restricting the use of larvicides has not prevented the development of resistance in some regions. Stopping the use of pyrethroids at the beginning of the 2000s has not brought change on the status of susceptibility to this class of products until 2009.

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