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CONTROLLING THE INTERACTION BETWEEN WILD AND TRANSGENIC MOSQUITOES

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Abstract. The development of transgenic mosquitoes, that are resistant to diseases, may provide a new and effective tool of diseases control. This approach relies on transgenic mosquitoes being able to survive and compete with wild-type populations. These transgenic mosquitoes carry a specific code that inhibits the plasmodium evolution in his organism. In this paper, a nonlinear control strategy is proposed to indicate how the genetically modified mosquitoes should be introduced in the environment. The numerical simulations show the effectiveness of the proposed control.

Keywords. mathematical modeling, malaria, transgenic mosquitoes, optimal vector control

1 Introduction

Vector borne diseases have affected many countries, mainly those who are poor, but due to global warming, there is a real risk of these diseases to appear in regions where they have already been eradicated or even in those where the normal environmental conditions would never have allowed its existence.

Some efforts have been made to control tropical diseases such as dengue fever, malaria and others. Even these diseases are not lethal for most of the cases; the consequences of an epidemic boost are very serious.

Scientists are working in vaccines, new drugs, biological and chemical insecticide and other strategies to erradicated diseases and/or their intermediate hosts. Due to the evolution of genetic studies, it has been possible to obtain genetically modified mosquitoes refractory to some diseases. These new insects should couple with wild mosquitoes and spread out the gene that blocks the transmission chain. This research has advanced quickly and a chronological line of main results is shown in [4].

The development of transgenic mosquitoes, which are unable to transmit diseases may provide a new and effective means of diseases control. Such approach relies on transgenic mosquitoes being able to survive and compete with wild-type populations. These transgenic mosquitoes carry a specific code that inhibits the plasmodium evolution in his organism. It seems that this characteristics is hereditary and consequently the disease fades away after some time.

In the last years, the genetic modification of malaria vectors has been very prominent. The first Anopheles mosquitoes refractory to malaria were engineered in 2002 with a technique developed by Catteruccia *et al* [2]. Once transgenic mosquitoes are released, interactions between the two populations and inter-specific mating between the two types of mosquitoes take place.

The simple mathematical model for interacting wild and transgenic mosquito populations based on systems of difference equations was formulated in [3]. The generation overlapping and a variable environment were not considered in this model. In [9] a non-autonomous continuous-time mathematical model was presented. In that model the transgenic mosquitoes were considered to be in a single population and, similarly to the wild population, its dynamics followed a seasonal pattern varying during the year. In [6] an optimal control problem was formulated and solved for this model, and the linear feedback control strategies indicated guidelines for the success of transgenic mosquitoes.

In this paper, a nonlinear control strategy is proposed to indicate how the genetically modified mosquitoes should be introduced in the environment. The numerical simulations show the effectiveness of the proposed control.

2 Mathematical model for interacting wild and transgenic mosquito populations

The interactions between wild and transgenic mosquito populations consider the following assumptions to prevail:

a all transgenic mosquitoes, without distinction of their zygosity, were considered as a single population group;

b populations of transgenic and wild mosquitoes are limited by the same carrying capacity and have the same fitness rate;

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