The role of increased gonotrophic cycles in the establishment of Wolbachia in Anopheles populations

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Wolbachia, a bacterium that infects insect populations, has been examined extensively in *Drosophila* populations and, in recent years, has garnered significant attention for its potential to reduce the spread of dengue in the *Aedes* mosquito population. Similar applications to *Anopheles* mosquitoes for the reduction of malaria have not been as thoroughly studied, as *Anopheles* were previously thought to be devoid of *Wolbachia* infection. The recent discovery, however, of *Wolbachia* in two separate wild *Anopheles* populations suggests further study is needed. We develop and analyze an ordinary differential equation model of *Wolbachia* infection in *Anopheles* mosquitoes, which demonstrate different reproductive phenotypes than *Aedes* mosquitoes when infected with *Wolbachia*. In particular, they do not show the hallmark cytoplasmic incompatibility phenotype - absence of viable offspring when infected males mate with uninfected females - or other standard sex-biasing phenotypes. Instead, evidence of increased speed of gonotrophic cycles by *Wolbachia*-infected females has been reported. We show that the ability for *Wolbachia* to invade for a basic reproductive number less than one $R_{pop} < 1$ found in other models, is significantly diminished here. However, the invasion threshold below $R_{pop} <1$ can be partially recovered with the increased speed of laying eggs, as incorporated through gonotrophic cycles. Our results highlight the need for further experimental and theoretical work if *Wolbachia* is to be considered as a form of malaria control.