Accounting for heterogeneity in wild adult samples to measure insecticide resistance in Anopheles malaria vectors

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Systematic, long-term, and spatially representative monitoring of insecticide resistance in Anopheles malaria vectors is needed to quantify the impact of insecticide resistance on malaria transmission, and to combat failing interventions when resistance emerges. Resistance assays on wild-caught adult mosquitoes offer an alternative to the current protocols, and can be done cheaply, in a shorter time frame, and in the absence of an insectary. We developed a discrete-time deterministic mosquito lifecycle model to simulate different types of insecticide assays and to evaluate the bias in insecticide resistance bioassays using either adult-captured or larval-captured samples. We incorporated non-lethal effects of insecticide exposure that were demonstrated in laboratory experiments. Using output from this model, we simulated assays from either larval-captured or adult-captured samples. We found that the bias in adult-captured assays depended on the level of insecticide resistance in the population, rather than spatial structure of the population or insecticide coverage. Using the model, we compared the results of these assays to true resistance as measured by the presence of the resistance allele, and constructed a correction model that can be used to reduce bias in adult-sampled assays. In a sample of 100 test mosquitoes, simulated 1000 times, we found that compared to adult-captured assays (MSE = 0.0059), larval-captured assays were a better measure of true resistance (MSE = 0.0018). Using the correction model, we were able to improve the accuracy of the adult-captured assay results (MSE = 0.0038). These results show that adult-captured bioassays—which have logistical advantages over the standard larval-captured assays—can be improved using a simple mathematical approach and used to inform resistance monitoring programs.

1. What is your pathogen? Multiple options possible (e.g. if working on coinfections)

Protozoan : Malaria

2. On a scale of 1-5 is your work mostly eco/epidemiological or evolutionary? 2

3. On a scale of 1-5 is your work mostly theoretical or experimental/empirical? 2