Windows of Selection:
How does selection pressure for insecticide resistance change in the months after spray and net deployments?

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Window of selection

- **genotype**: resistant (rr), susceptible (ss)
- **mortality**
  - High concentration: Short time after application
  - Low concentration: Long time after application
Laboratory experiments - concentration

*Anopheles gambiae* exposed to deltamethrin

- Mortality %
- Concentration % (declining)
- Hours after exposure

- 10x
- 5x
- 1x

<table>
<thead>
<tr>
<th>Concentration % (declining)</th>
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<td>0.800</td>
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- Resistant
- Susceptible

Strain
Windows of selection examples from the Literature: *Anopheles gambiae* strains and permethrin concentrations

Windows of selection for free flying *Anopheles gambiae* in sprayed experimental hut trials

Window of selection for insecticide treated nets.

Window of dominance

• All earlier slides just considered ‘resistant’ versus ‘susceptible’ strains.

• Insects are diploid so may be RR, RS (heterozygous) or SS.
Window of dominance

- High concentration (Short time after application)
- Low concentration (Long time after application)
- Insecticide

Genotypes:
- rr
- sr
- ss

Mortality and dominance levels vary with time and genotype.
Evolution of resistance likely to be greatest within the window of dominance

**selective advantage**

**estimated time-to-resistance**
Window of dominance for *Culex quinquefasciatus* larvae exposed to permethrin.

Potential lessons from ‘high-dose standard’ in transgenic crops

Killing heterozygotes is key.

Some success at limiting resistance evolution.

Definitions of ‘high-dose’ (US EPA):

Theoretical: dominance < 0.05
Practical: mortality of susceptible insects >= 99.99%

“... if Bt plants do not kill all or nearly all susceptible insects, they probably will not kill nearly all insects that are heterozygous for resistance.”

Conclusions

• Windows of selection are extensive in terms of concentration and time (months years)

• Evolution of insecticide resistance likely to be greatest within windows of dominance where mortality of SR < SS

• Measurement of changing mortalities of RR, SR, SS genotypes over time needed to answer questions like:

Will the evolution of resistance be minimised by
a) using a higher concentration insecticide or
b) replacing a lower concentration one more frequently?