

The role of windows of selection and windows of dominance in the evolution of insecticide resistance.



Andy South, Rosemary Lees, Gala Garrod, Jessica Carson, Ian Hastings
Liverpool School of Tropical Medicine, Liverpool L3 5QA, United Kingdom.



Window of selection

- Public health insecticides kill over months and years but concentrations and mortality decline with time.
- Mortality of resistant forms declines before that of susceptible ones.
- This leads to a **'window of selection'** a period where susceptible mortality is higher than resistant and evolution of resistance occurs (Fig 1).

An experiment

- Deltamethrin was sprayed at recommended concentration onto tiles of three substrates and kept in the lab mimicking field conditions.
- Resistant and sensitive strains of three mosquito species were exposed to the tiles over 18 months.

Results

Differential mortality of sensitive and resistant strains was present immediately after treatment and persisted for at least 18 months (Fig 2).

A literature search for past studies consistently found the same effect i.e. long durations of differential selection (see [1] for full discussion).

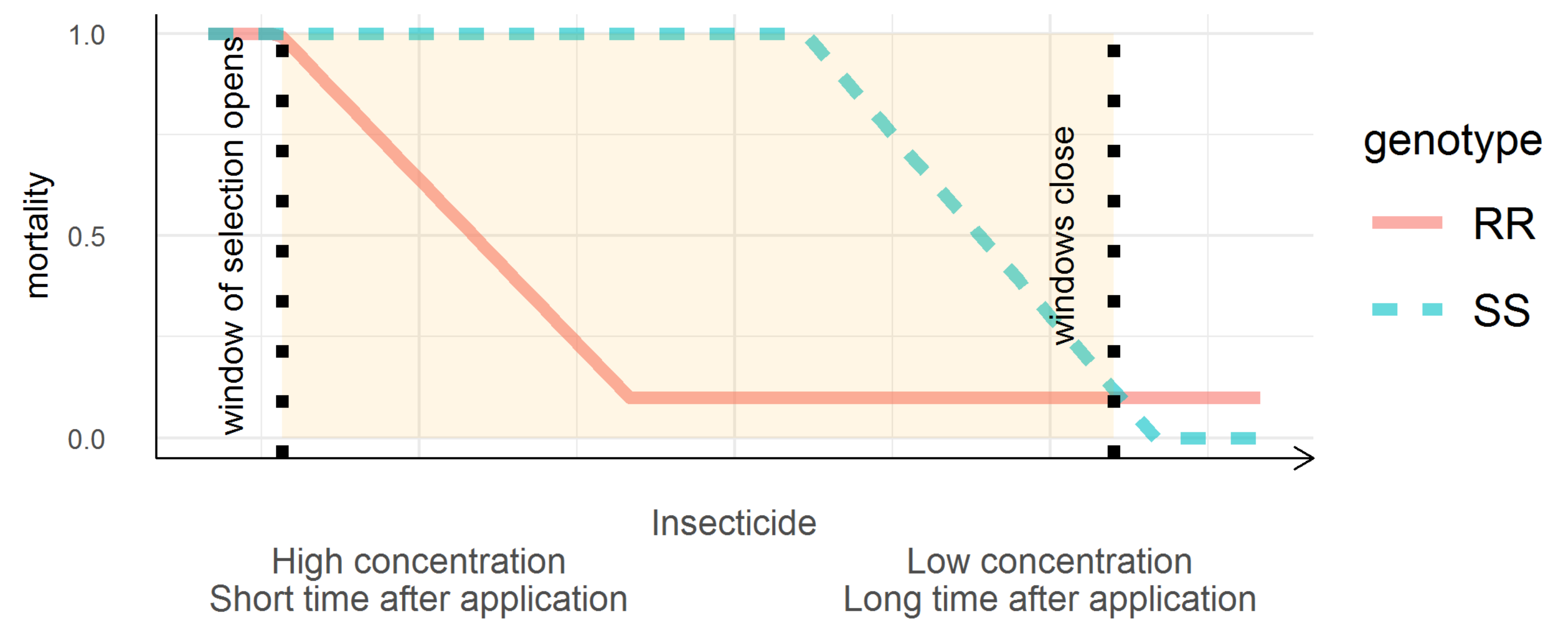


Fig 1

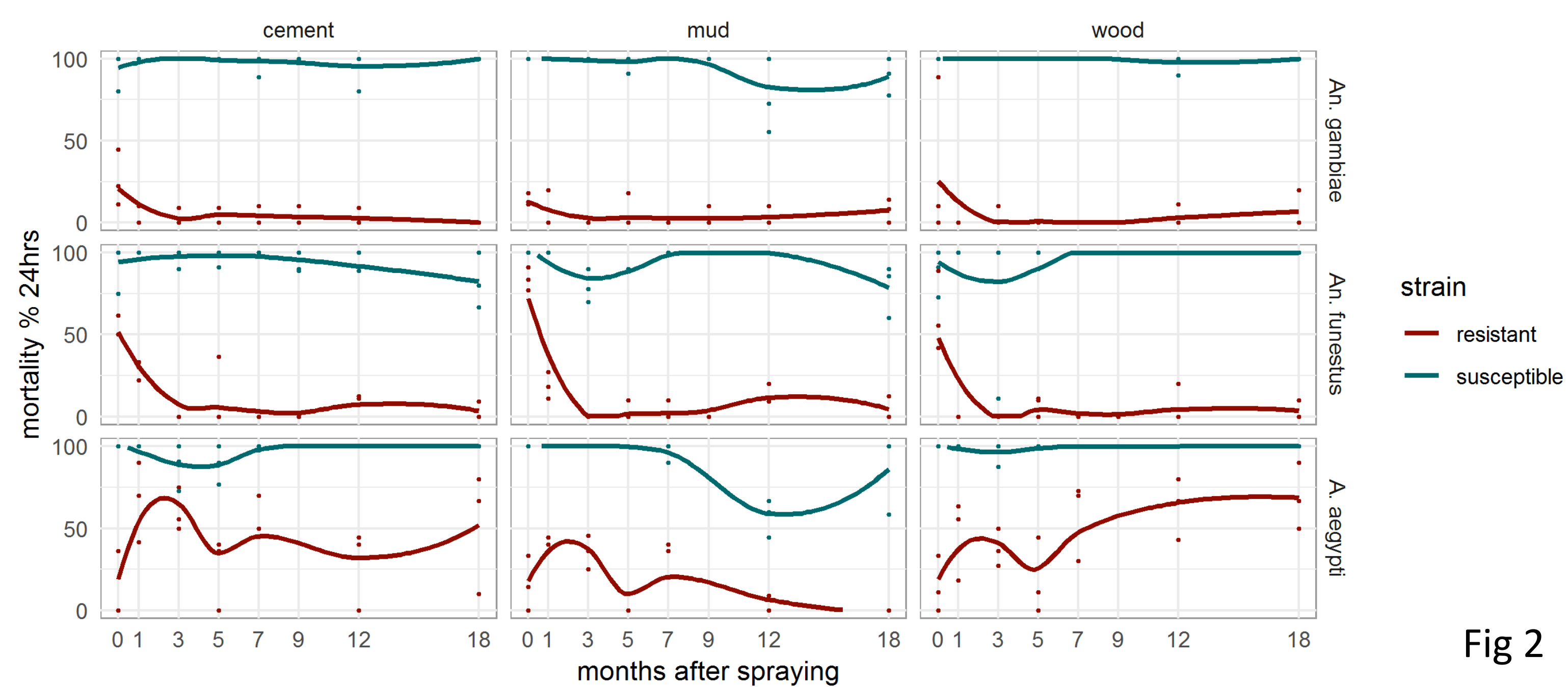


Fig 2

Window of dominance

- Where there is information on mortality of heterozygotes (SR), it declines after the susceptible (SS) opening a 'window of dominance' (Fig 3 right).
- Dominance : 0 SR has same mortality as SS
0.5 SR mortality is half-way between the SS and RR
1 SR mortality is the same as the RR.
- As dominance increases, selection and spread of insecticide resistance become much, much higher (Figs 4 & 5 below).**

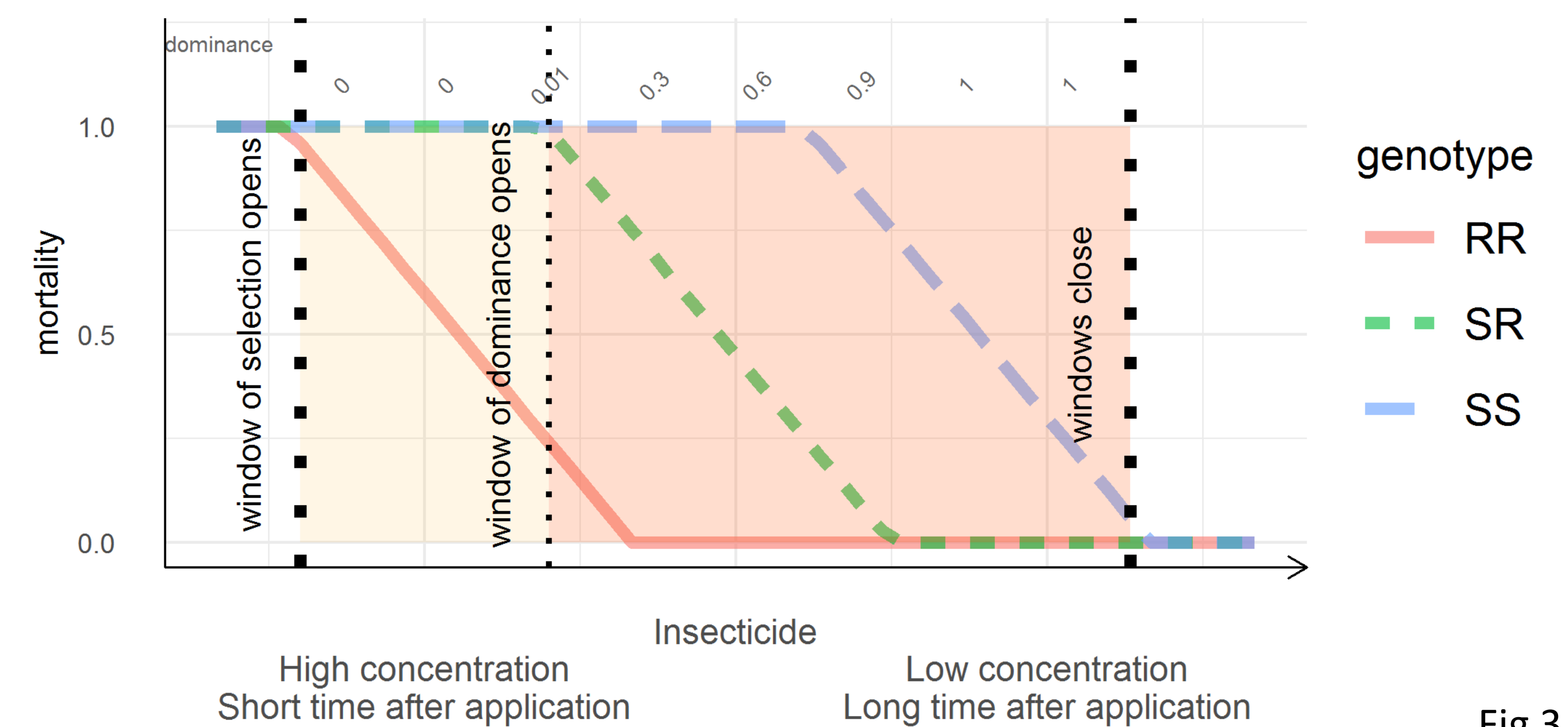


Fig 3

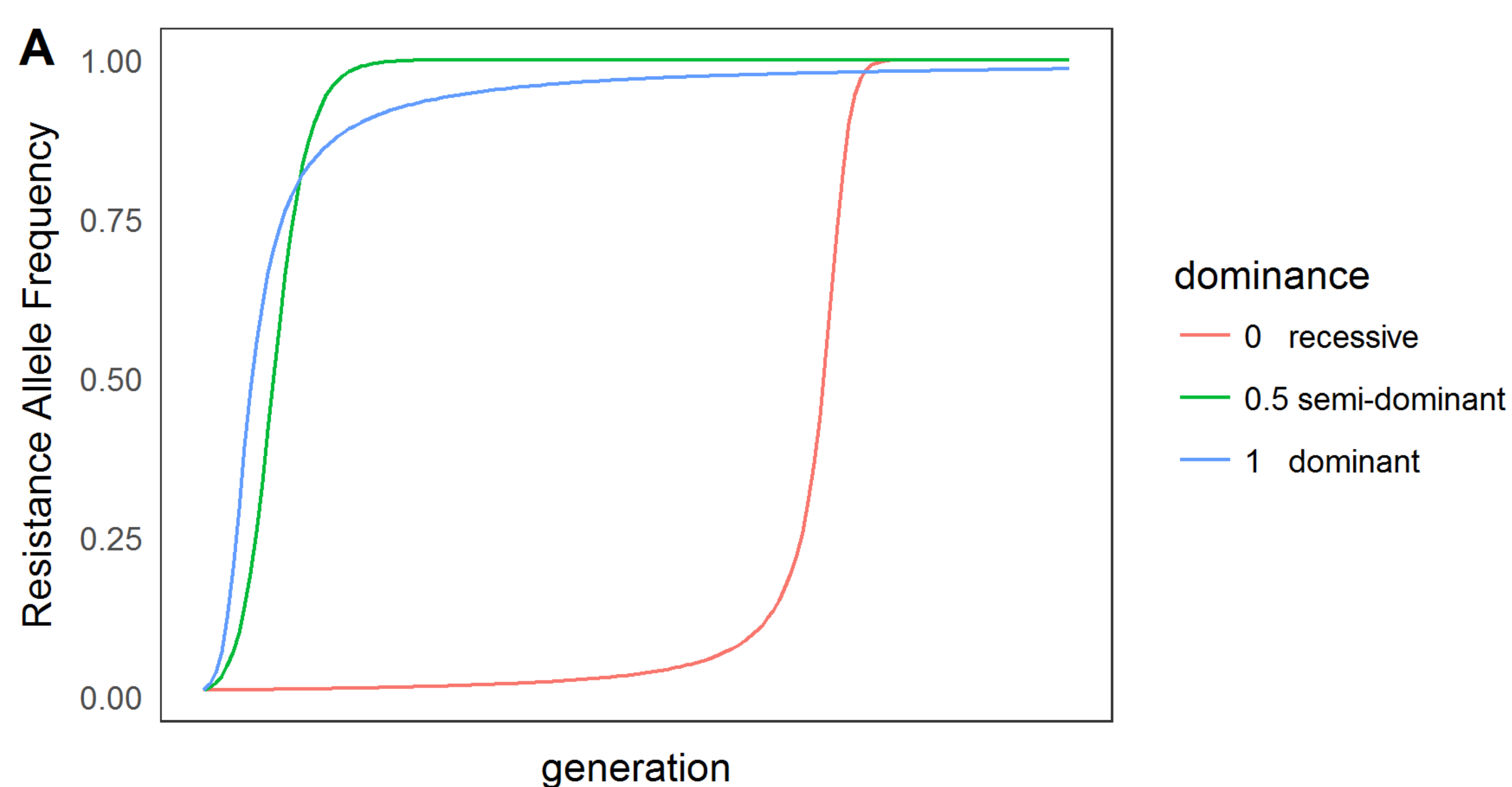


Fig 4 How increasing dominance drives the rapid spread of resistance (adapted from Figure 1 of [2]; see also Figure 3 of [3]).

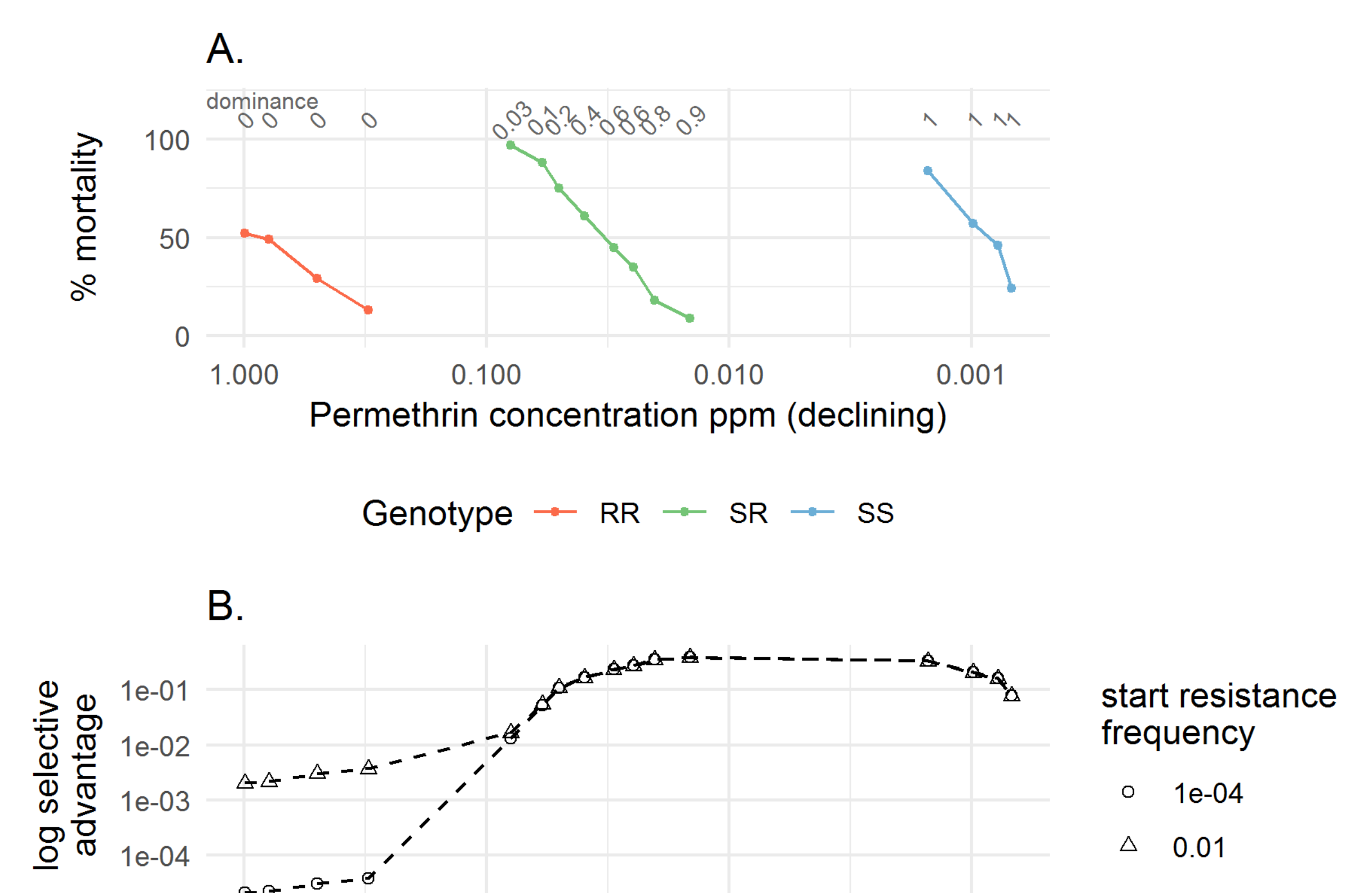


Fig 5. A window of dominance from Georgiou and Taylor [4]. Permethrin mortality of *Culex quinquefasciatus* larvae. A. mortality B. our estimates of selection pressure driving resistance: note log scale and the rapid rise when dominance increases above zero.

Conclusions

- Most insecticide resistance management originates in agriculture, where insecticides are usually short-lasting. This explains why insecticide persistence has received relatively little attention as a driver of resistance.
- The evolution of resistance to public health insecticides occurs within windows of selection.
- When resistance is due to a single gene, evolution will be fastest within windows of dominance. (for polygenic resistance a similar peak in evolution is expected as insecticide concentrations decline).**
- Measuring windows of selection and dominance can quantify how different insecticide use strategies promote the evolution of resistance.

References and acknowledgements. [1] South A, Lees R, Garrod G, Carson J, Malone D, Hastings I. The role of windows of selection and windows of dominance in the evolution of insecticide resistance in human disease vectors. *Evolutionary Applications*. 2019. [2] Levick B, South A, Hastings IM. A Two-Locus Model of the Evolution of Insecticide Resistance to Inform and Optimise Public Health Insecticide Deployment Strategies. *PLoS Comp Biol*. 2017;13(1):e1005327.[3] Gould F, Brown ZS, Kuzma J. Wicked evolution: Can we address the sociobiological dilemma of pesticide resistance? *Science*. 2018;360(6390):728-32. [4] Georgiou GP, Taylor CE. Factors influencing the evolution of resistance. In: Agriculture Bo, editor. *Pesticide Resistance Strategies and Tactics for Management* Washington D.C.: National Academy Press; 1986. p. 157-69.. This work was funded by the Innovative Vector Control Consortium.

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