Rothamsted Research

where knowledge grows

Combating insecticide resistance in major UK pests: modelling section

Joe Helps, Frank van den Bosch, Neil Paveley

Start: 1/1/2013

End: 31/7/2016

defra Department for Environment Food and Rural Affairs

HSE

AHDB Agriculture & Horticulture Development Board

AHDB Cereals & Oilseeds

AHDB Potatoes

AHDB Horticulture

PGRO

BBRO

BBSRC bioscience for the future

ADAS

Rothamsted Research

Project aim

- Key questions:
  - Are mixtures beneficial?
  - First need to understand what is the effect of dose on resistance?

1. Build a model of insecticide resistance
2. Explore various measures relating to both:
   - Providing effective control of populations
   - Delaying build up of resistance

Insects in the UK

- Peach-potato aphid
- Potato aphid
- Grain aphid
- Pea aphid
- Rose-grain aphid
- Currant-lettuce aphid
- Glasshouse whitefly
- Two-spotted spider mite
- Western flower thrips
- Diamondback moth
- Leaf miner
- Pollen beetle
- Cabbage stem flea beetle
- Wheat bulb fly
- Orange wheat blossom midge
- Pea moth
- Codling moth
- Pea and bean weevil

Generations per year

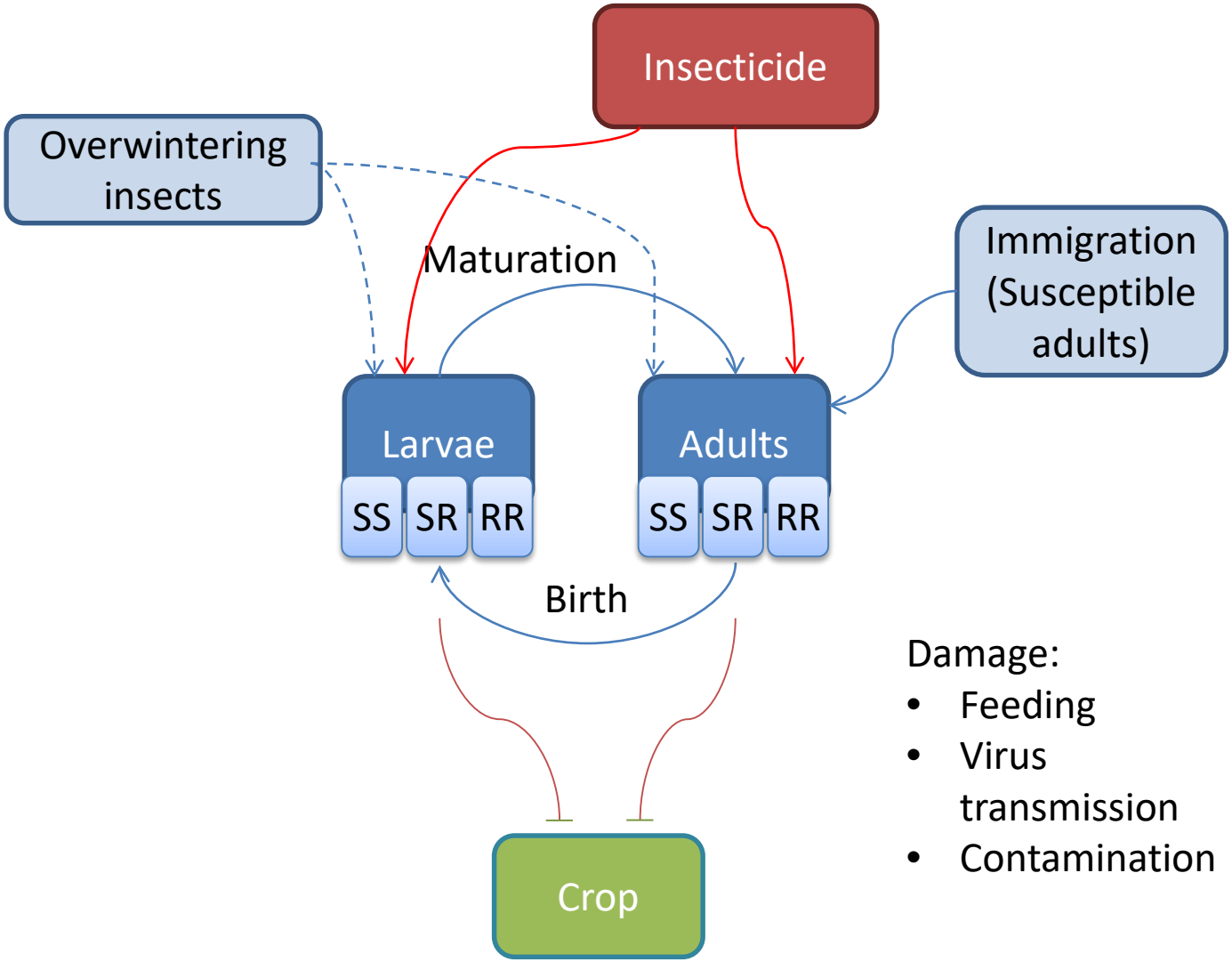
Multiple | Single

Asexual

Asexual / Sexual

Sexual

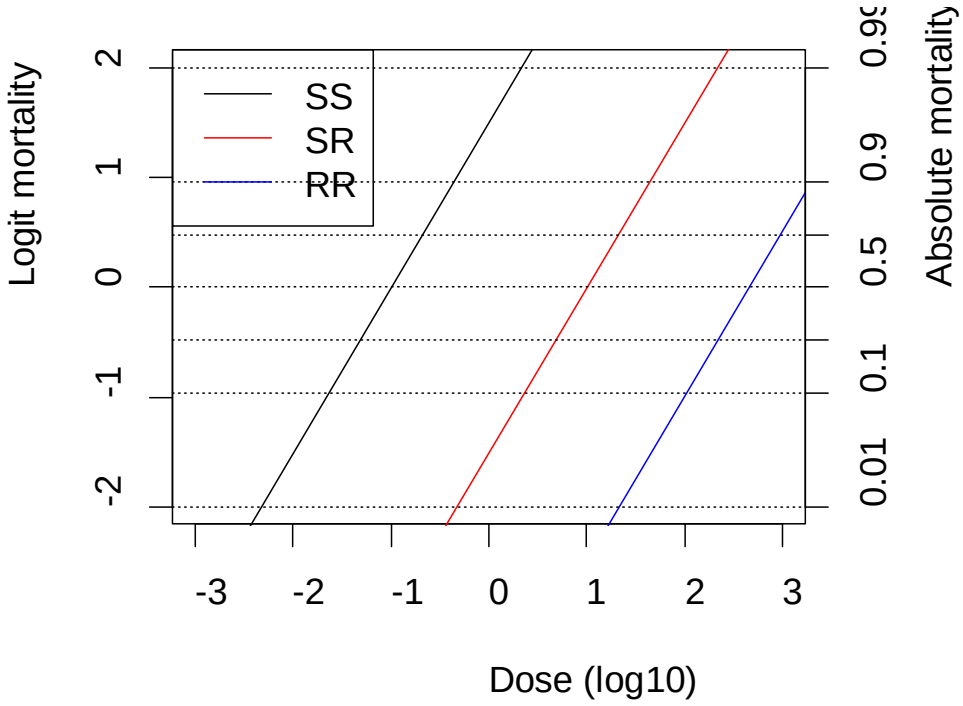
Model introduction

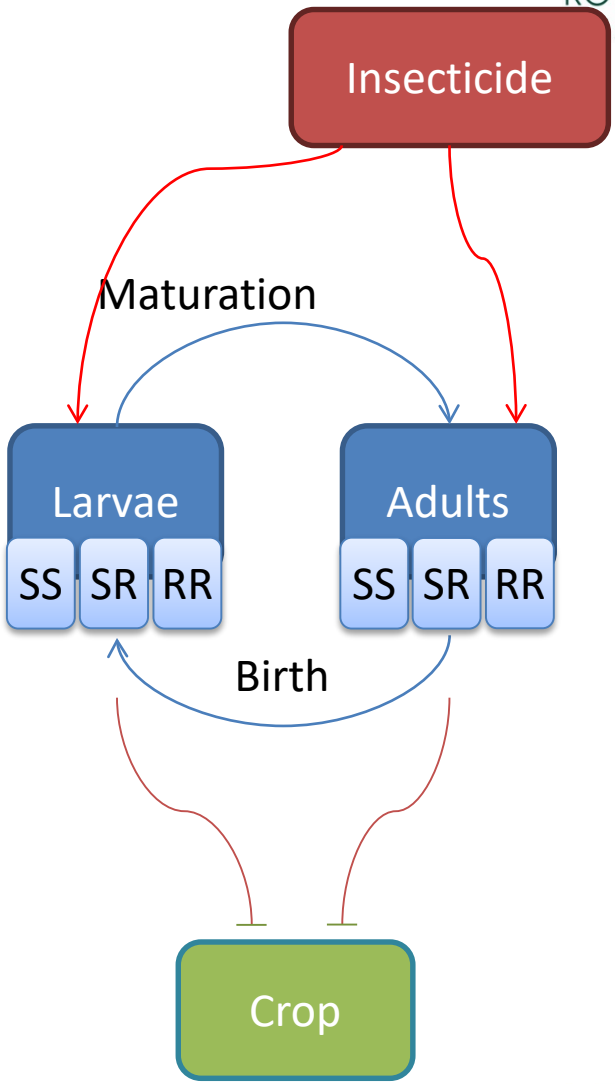


Damage:

- Feeding
- Virus transmission
- Contamination

Model introduction

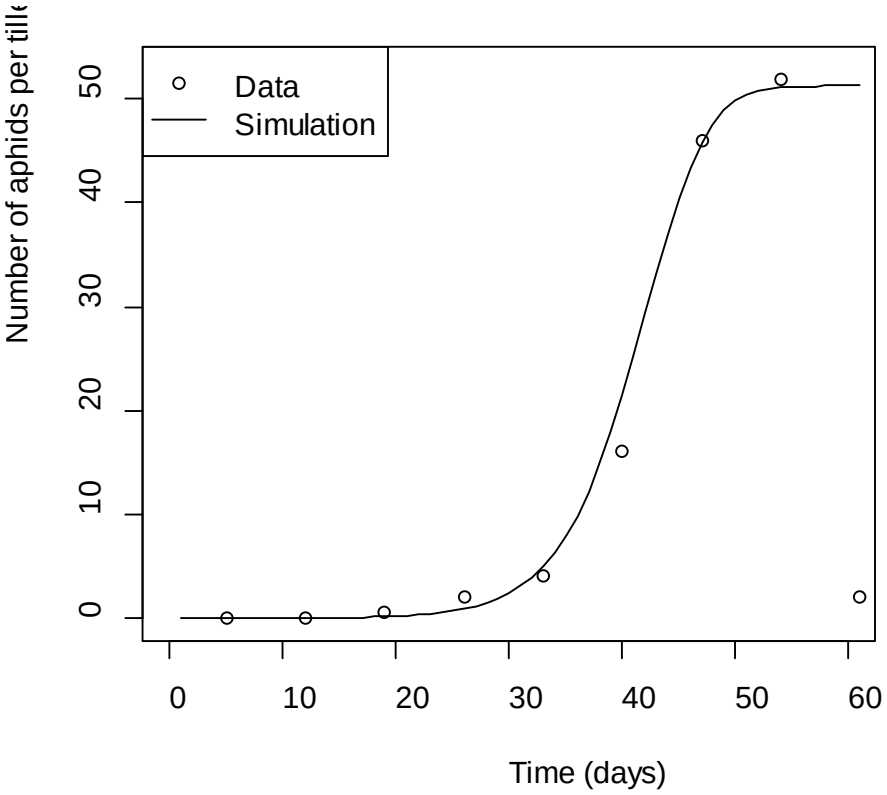




Simulations

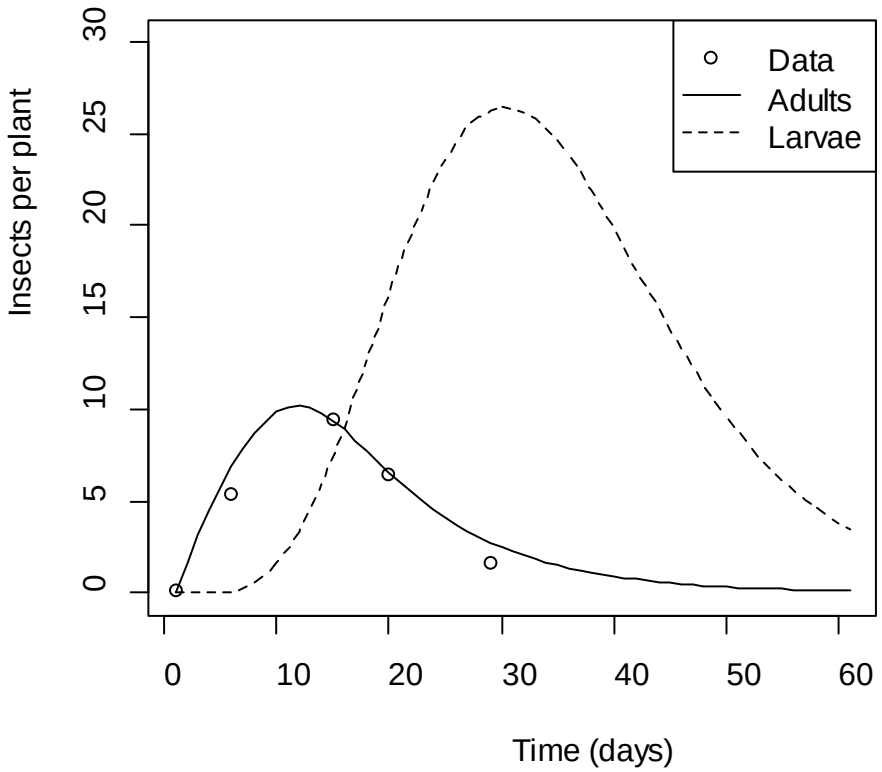
ROTHAMSTED RESEARCH

Grain aphid



Data from Skirvin, D.J., Perry, J.N. & Harrington, R. Ecological Modelling, 96, 29-39

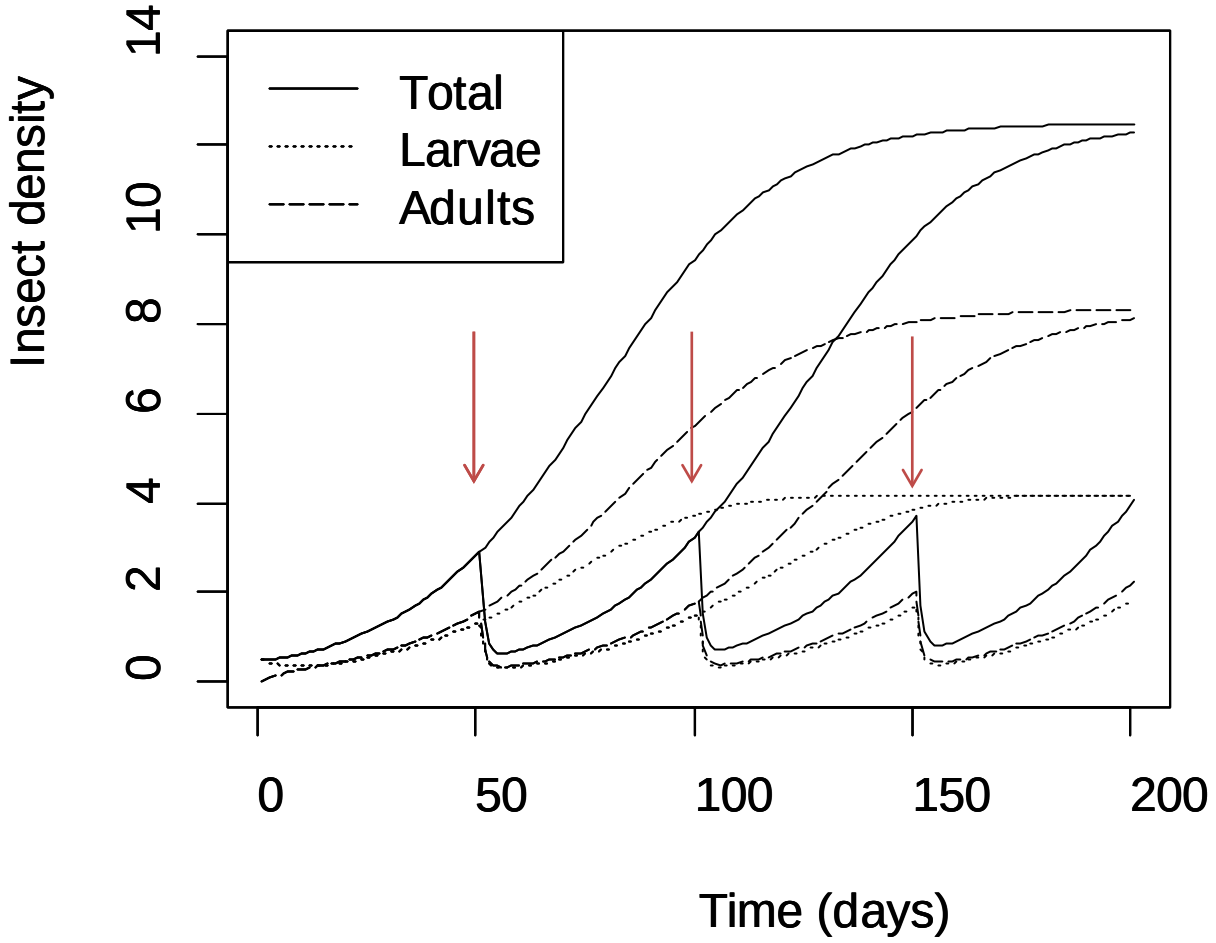
Pollen beetle



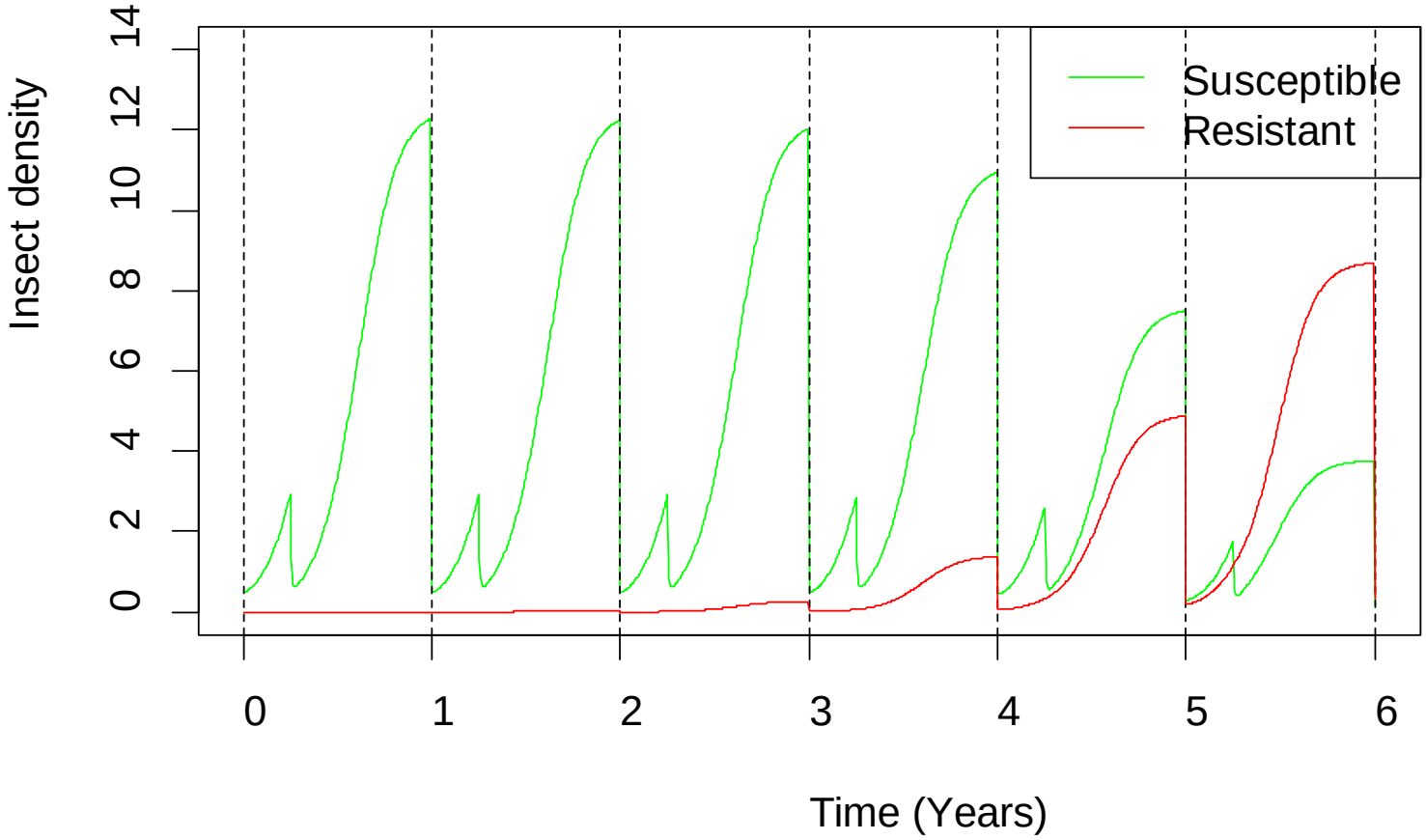
Data from Sam Cook, Rothamsted

BBSRC bioscience for the future

Model introduction



Model introduction



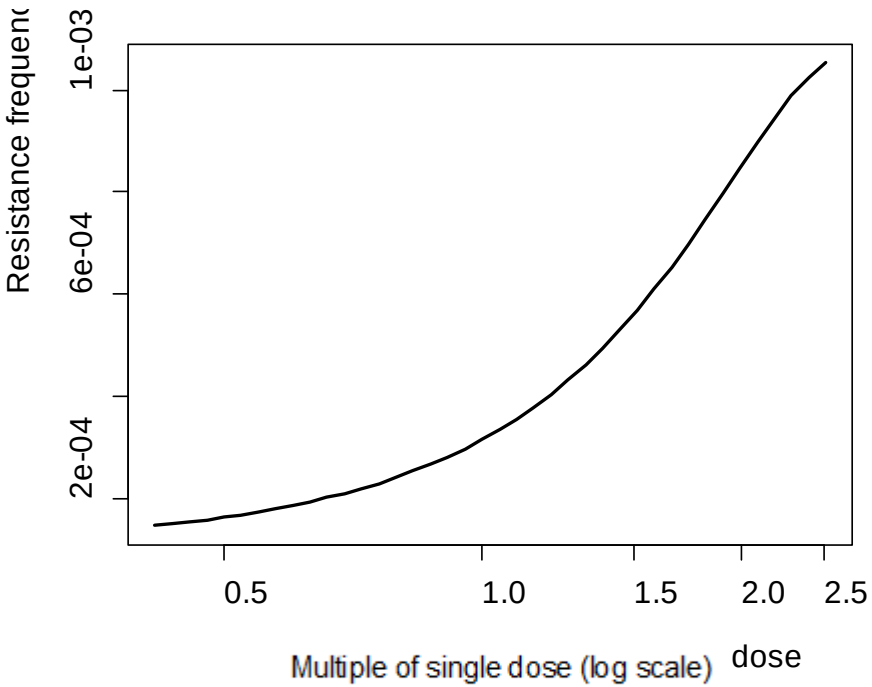
High dose hypothesis

- Does a high dose lead to reduced or increased selection for resistance?

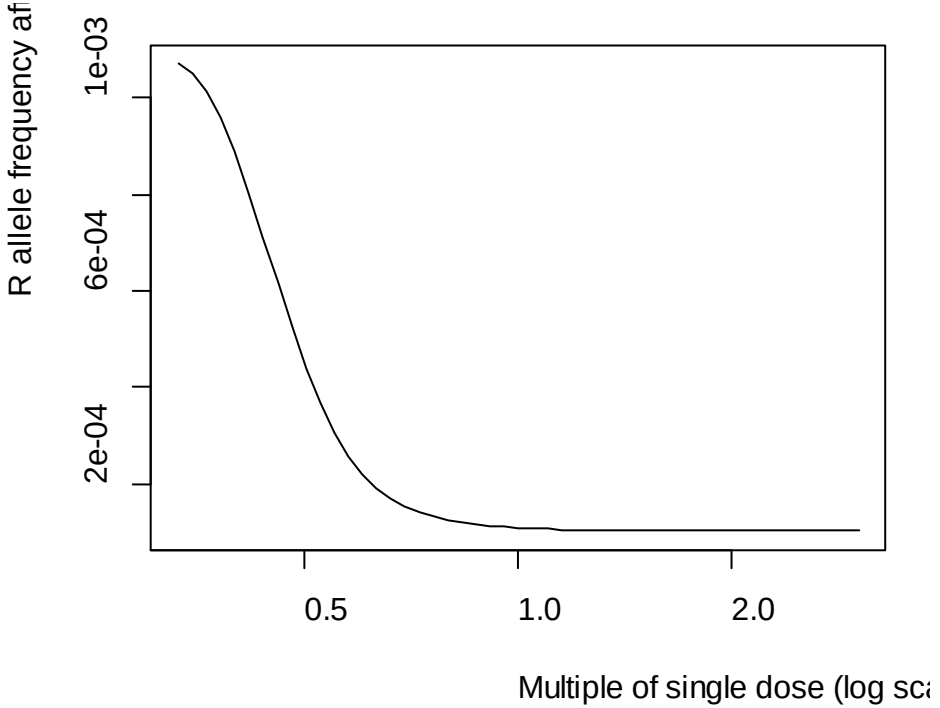
High dose hypothesis

- Applying a very high dose can lead to slower resistance frequency build up

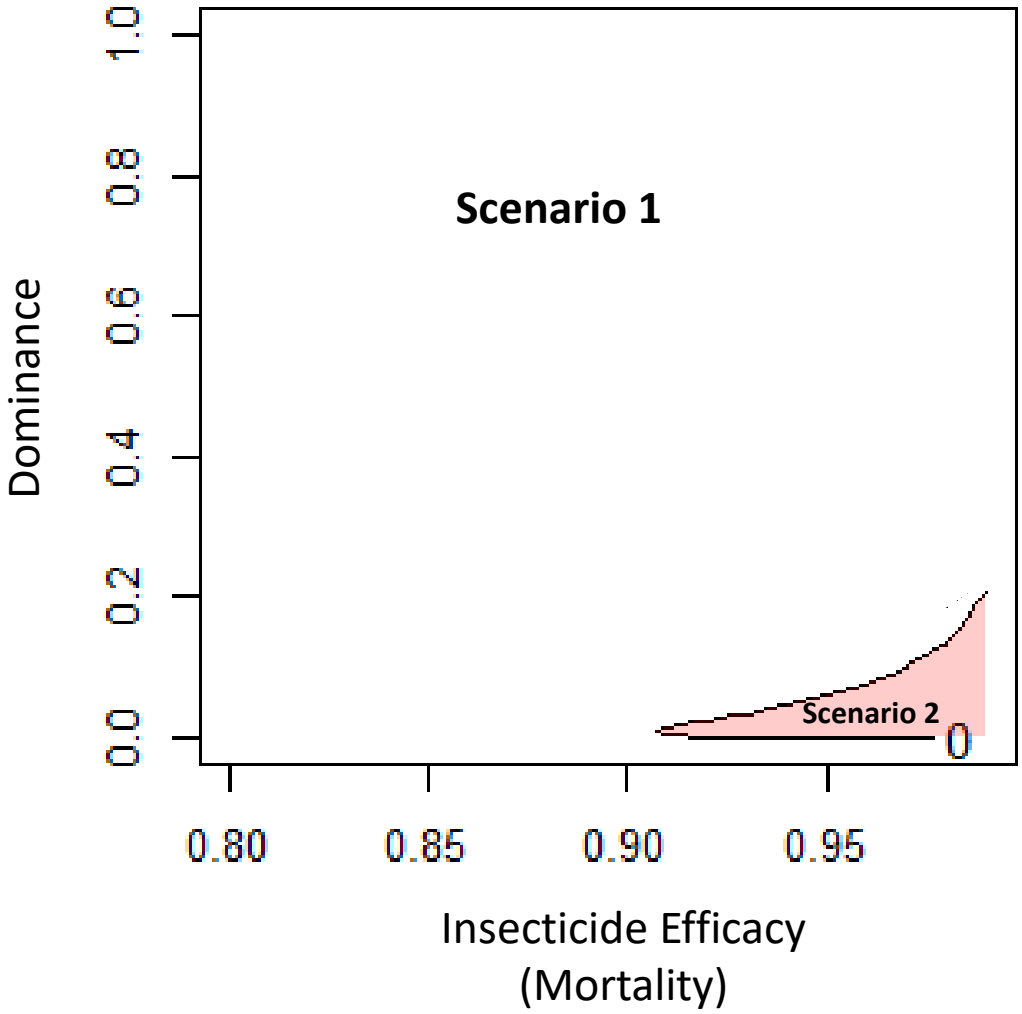
Scenario 1



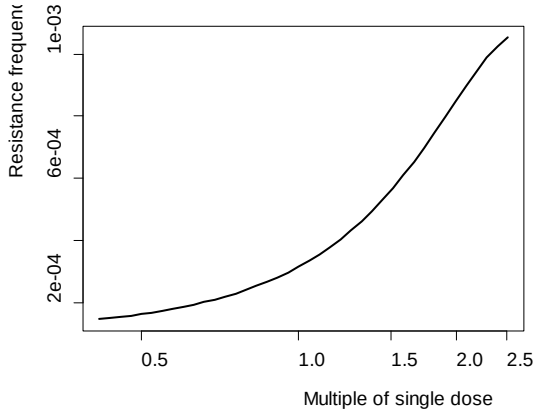
Scenario 2



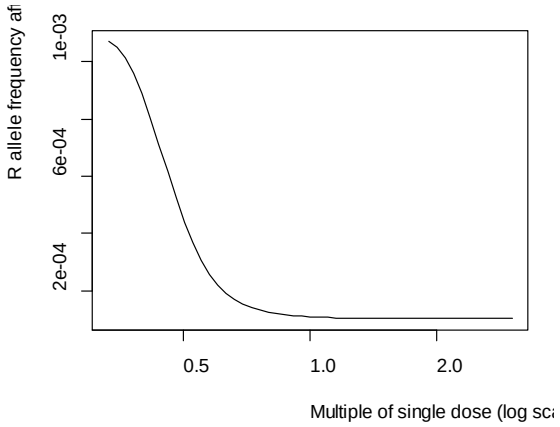
High dose hypothesis



Scenario 1



Scenario 2



High dose summary

- One important mechanism allows high dose to reduce selection
  - Immigration from external source

- Under most parameter combinations tested, lowering the dose will lower the selection for resistance

Resistance management & yield

- Coupling control of the pest with resistance management

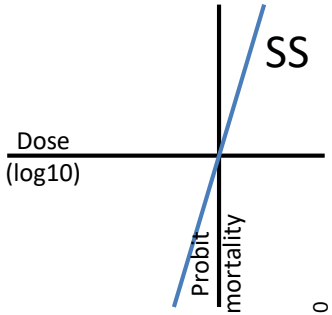
- **Effective life**
  - Number of years that the insecticide effectively controls the insect pest
  - Following results:
    - Number of years until yield loss (reduction in HAD) exceeds 20% (an arbitrary value)

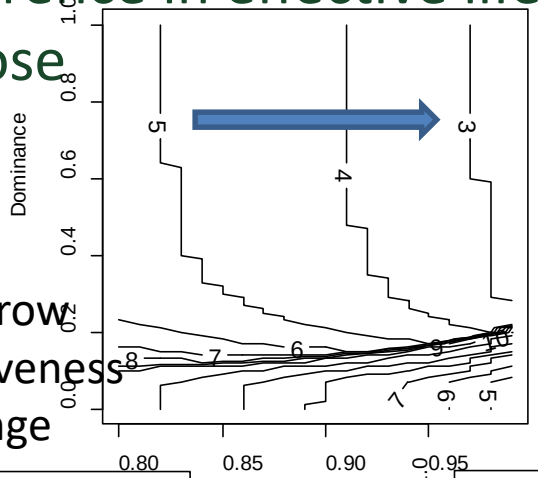
  - Still to consider:
    - Contamination
    - Virus infection

Exploring effective life

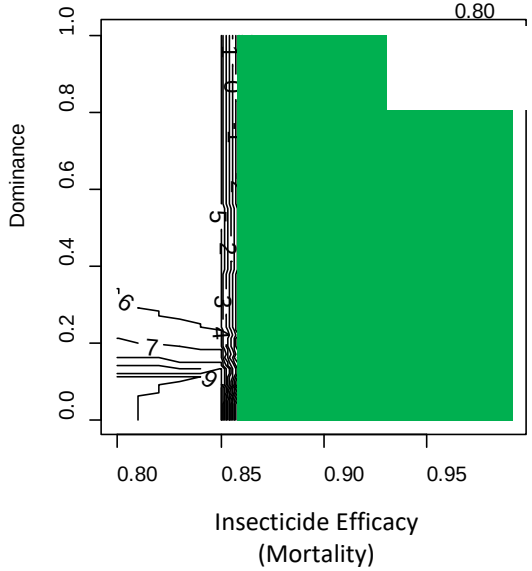
Asexual; No immigration

- Graphs show effective life
- Graphs show difference in effective life between applying a full dose and a half dose

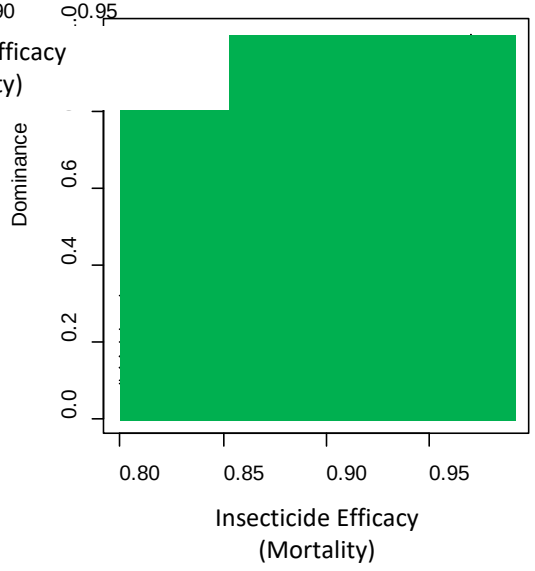


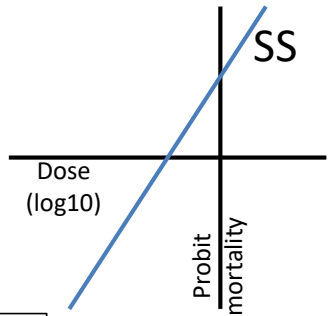


Narrow effectiveness range



Broad effectiveness range





Conclusions about half dose

- Preliminary conclusion:
  - When the insecticide dose can be reduced without incurring unacceptable yield losses, it will lead to reduced selection for resistance

- Is there data available?
- Possible to test in cage / field experiments?

Two insecticides

ROTHAMSTED RESEARCH

- Two insecticides

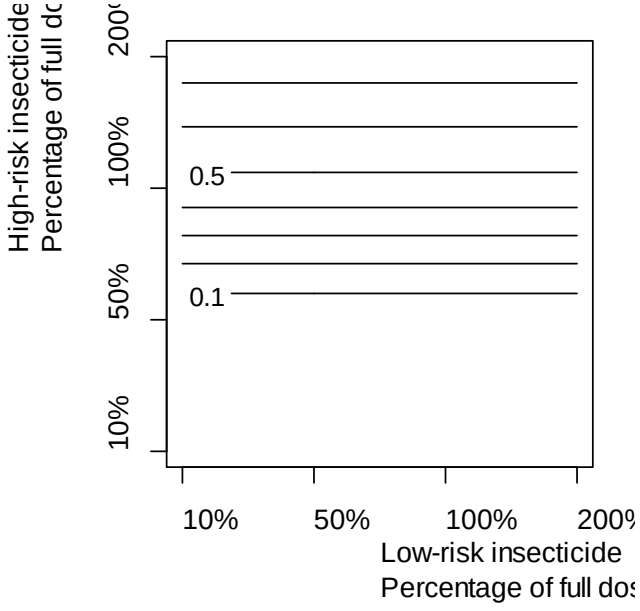
- What is the consequence of mixing the two insecticides when:
  - Resistance is developing to only one of the insecticides
  - Resistance is developing to both insecticides

BBSRC bioscience for the future

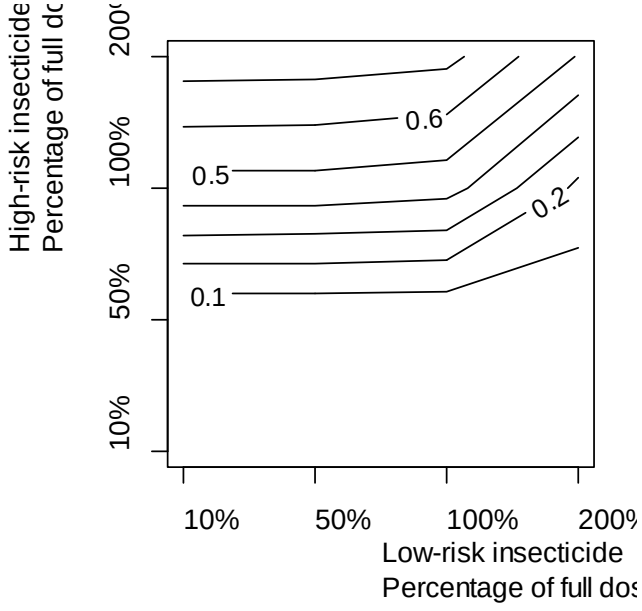
Evolution against one insecticide in the mixture

- Three key determinants:
  - Emergence from an overwintering population
  - Immigration from an untreated population
  - If an insect stage (larvae / adults) is present but not affected by the insecticide

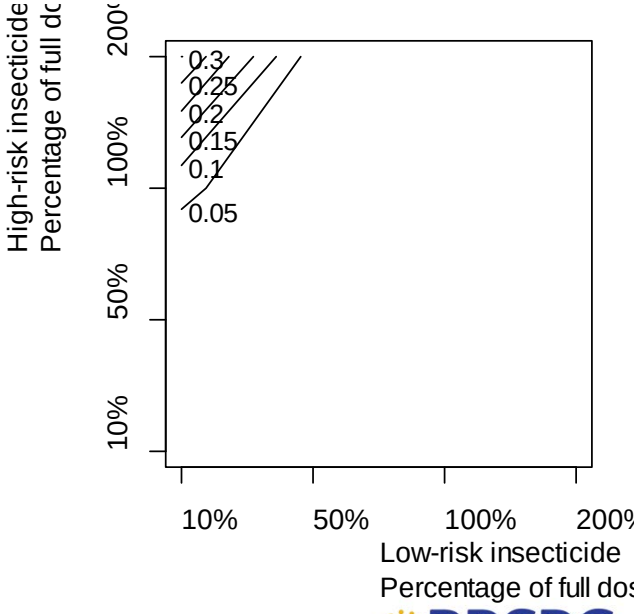
- No emergence
- No immigration
- All stages susceptible



- With emergence
- No immigration
- All stages susceptible



- No emergence
- With immigration
- All stages susceptible



R allele frequency after 5 years

Future work

- High-risk mixtures
- Exploration of the effective life of mixtures
- Testing different strategies for two insecticides:
  - Mixtures
  - Alternation (within year)
  - Rotation (between year)
  - Sequential use
- Validation

Conclusions

- We have developed a tool to test management strategies
- With a single insecticide spray:
  - Reduce dose as much as possible without compromising control
- We are currently exploring additional management strategies
- Determine critical characteristics of insects
- Group insects by the optimal management strategy