Calculating Treatment Efficacy against Invasive Alien Species in Trade

Dr Mike Ormsby

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

The Problem …..

The International Forest Quarantine Research Group (IFQRG) has been asked by the Secretariat of the Food and Agricultural Organisation, International Plant Protection Convention to evaluate more suitable levels of efficacy for treatments on wood packaging material moving in international trade

Current efforts to tackle the long-standing problem

1. How to manage difficult to manage biosecurity risks?
   - e.g. Wood borers, pests in WPM

2. How to replace existing management methods?
   - e.g. phase-out of methyl bromide

How good was Methyl Bromide?

We often do not know!

Either:

1. Test to see how good MethBr is then duplicate with a new treatment

or

2. Work out how good we want the new treatment to be.

No one wants to work on Methyl Bromide

How good is good enough?

Baker (1939) established probit 9 (at the 95% level of confidence) as the default level of efficacy for treatments applied in international trade.

Authors have begun to challenge this default level of efficacy as being arbitrary and, depending on the IAS in question, either failing to adequately manage the risks in trade or over managing the risks and imposing unnecessary costs on trade (Landolt *et al*. 1984, Livingston 2007, Follet & McQuate 2007, Schoremeyer *et al.* 2011).

How good is good enough?

Look at pest biology (biological systems approach) to calculate required treatment strength

How many pests do we need to kill (ED)?

= Aggregation size x infestation level ÷ MPL

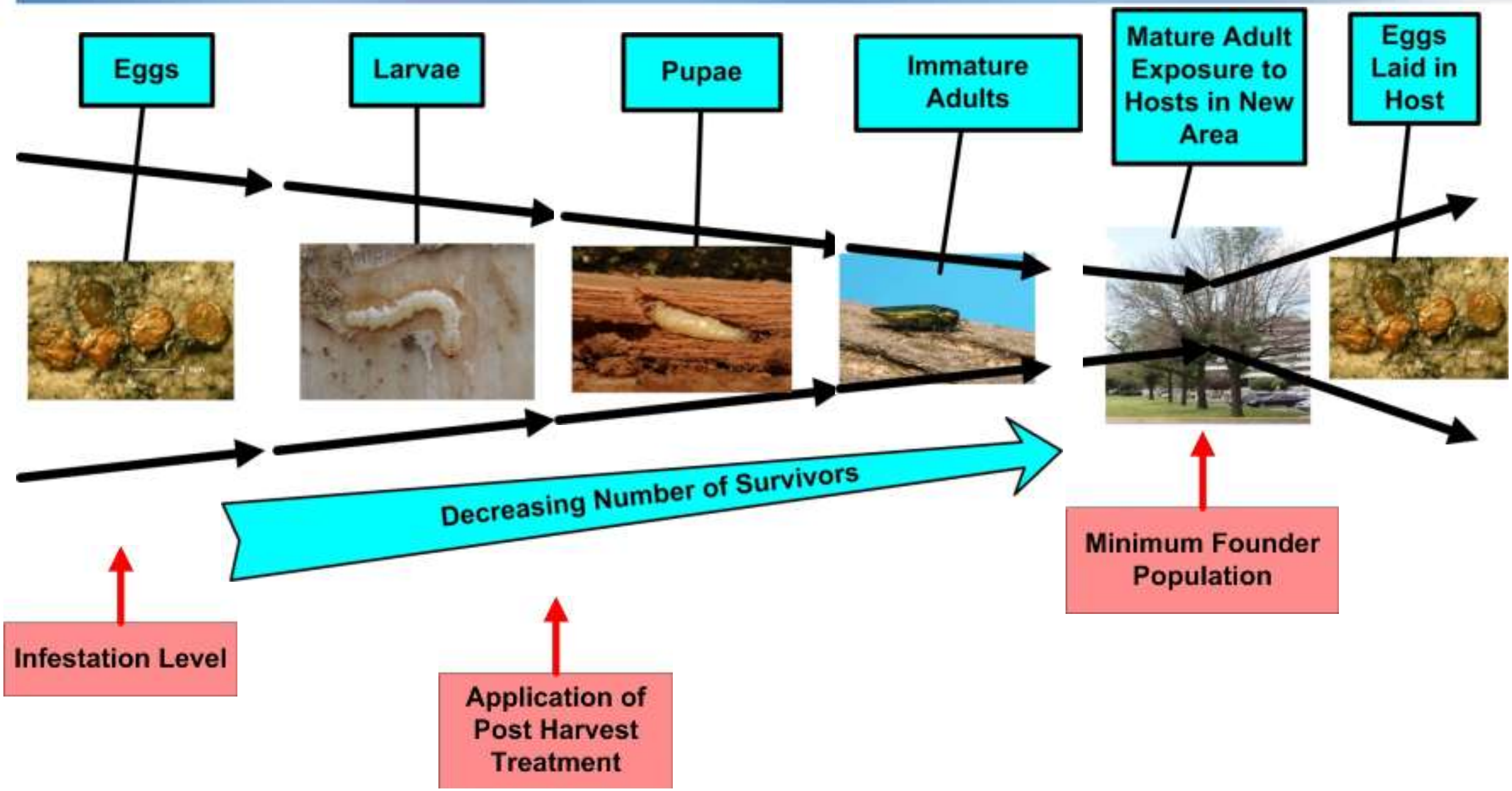
Aggregation size or volume is considered the largest number of invested units (e.g. pieces or units of wood packaging) likely to be found together in a new area (quarantine area) and thus allow infesting organisms to breed and establish a population.

How good is good enough?

<u>Infestation level</u> is the most likely worst-case level of infestation to be found in those infested units (e.g. pieces or units of wood packaging).

<u>MPL</u> (Maximum pest limit) is the number of pests required to establish a new population (how many survivors are required to meet and breed and establish a population given the Allee affect).

An example Biological System Pathway



Pictures of Emerald ash borer provided by the Natural Resources Canada, Canadian Forest Service and David Cappaert, Michigan State University, www.forestryimages.org

Biological systems and the maximum pest limit

Baker *et al*. (1990): The first published instance of the use of the *maximum pest limit* concept in determining the level of risk mitigation for an import pathway.

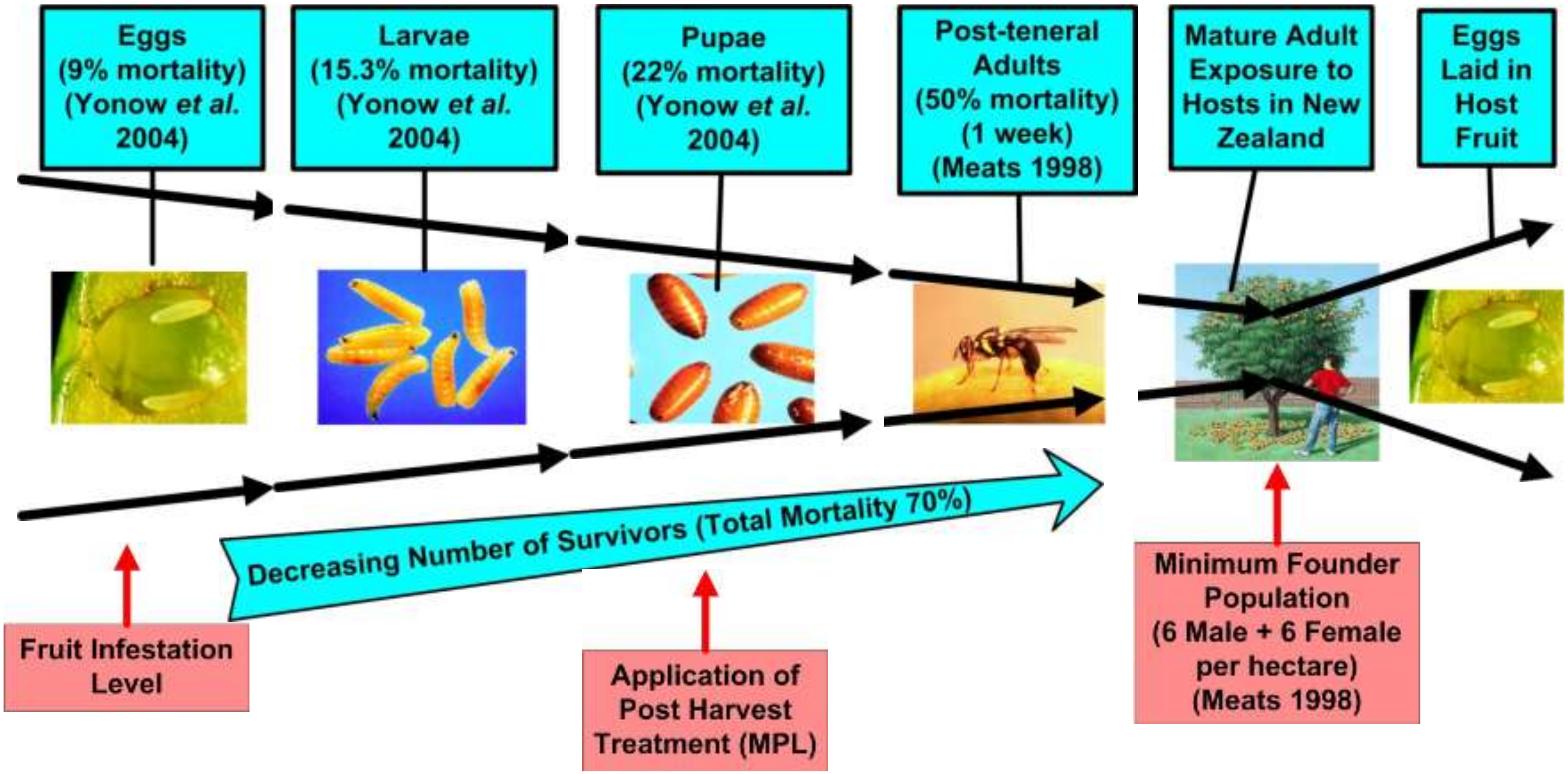
Schoremeyer *et al*. (2011) provided a case study of the maximum pest limit concept for the emerald ash borer (*Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae)) and the Asian longhorned beetle (*Anoplophora glabripennis* Motschulsky (Coleoptera: Cerambycidae)).

Example: Fruit Fly in Trade

Ormsby (2012) reviewed the work of Baker *et al*. (1990) against more up-to-date information on trade volumes and fruit fly biology

The technical paper calculated the MPL and the required treatment efficacy for *Bactrocera tryoni* (Froggatt) (Queensland fruit fly) on host fruit imported from Australia.

Example: Fruit Fly in Trade



Pictures of Queensland fruit fly provided by NSW Department of Primary Industries

Example: Fruit Fly in Trade

MPL =

Minimum Founder Population ÷

(1 - egg mortality) x (1 – larval mortality) x (1 – pupal mortality) x (1 – post-teneral adult mortality))

MPL =

$12 \div (0.91 \times 0.847 \times 0.78 \times 0.5) = 12 \div 0.3 = \underline{\mathbf{40}}$

BIOSECURITY NEW ZEALAND Ministry of Fisheries NZFSA MAF

Example: Fruit Fly in Trade

- Highest volume of suitable host material was tomatoes at an estimated 1,180,000 fruit
- Maximum fruit infestation rate of 1.136% after a pre-treatment inspection
- Average fruit infestation level of 20 eggs per tomato

For an estimate of the number of individual fruit flies in the imported host:

1,180,000 x 20 x 1.136% = **166,000** fruit flies

Example: Fruit Fly in Trade

The required treatment efficacy can then be calculated by dividing the number of target fruit fly individuals by the MPL

Treatment efficacy = 166,000 ÷ 40 = 1 survivor in **4,150** or an ED of **99.976%**

Example: Fruit Fly in Trade

Research to provide a 95% level of confidence that a treatment would achieve an efficacy of 99.976% (no survivors in 4,150 exposed individuals) would need to expose **12,450** individuals without any survivors (Couey & Chew 1986)

This compares favourably with Baker *et al*. (1990) who required a test size of **94,588** individuals for probit 9 security.

What information do we need?

1. Information to calculate Aggregation (volume) size
2. Information to calculate infestation levels
3. Information/evidence to determine MPL

Aggregation size (Volume)?

Using WPM examples:

Question for those in industry to answer

1) ~2 billion WPM (pallets, boxes, crates, etc.), moving each day.
2) ~800 million units of WPM are made new or repaired each year.
3) ~5,000 facilities that produce WPM for international trade
4) ~100,000 = largest concentration of WPM likely to be found at any one time and any one place.
5) ~250-300 units of international WPM (pallets, boxes, crates) aggregated in a single area.

Infestation Level?

Question of science

- Estimated 1000 pine wood nematodes per gram of wood
- *Pityogenes chalcographus* - 100 emergent adults per day

Any other information?

Maximum pest limit?

Question for science

- Life stage mortality rates and measuring the Allee effect in founder populations of IAS
- Much more difficult questions to answer but cleverly designed experiments should be able to provide some guidance
- Experience and observations can also provide the answers

Any other suggested sources?