



Entomopathogenic nematodes for control of Mediterranean fly *Ceratitis capitata*: prospects and limitations

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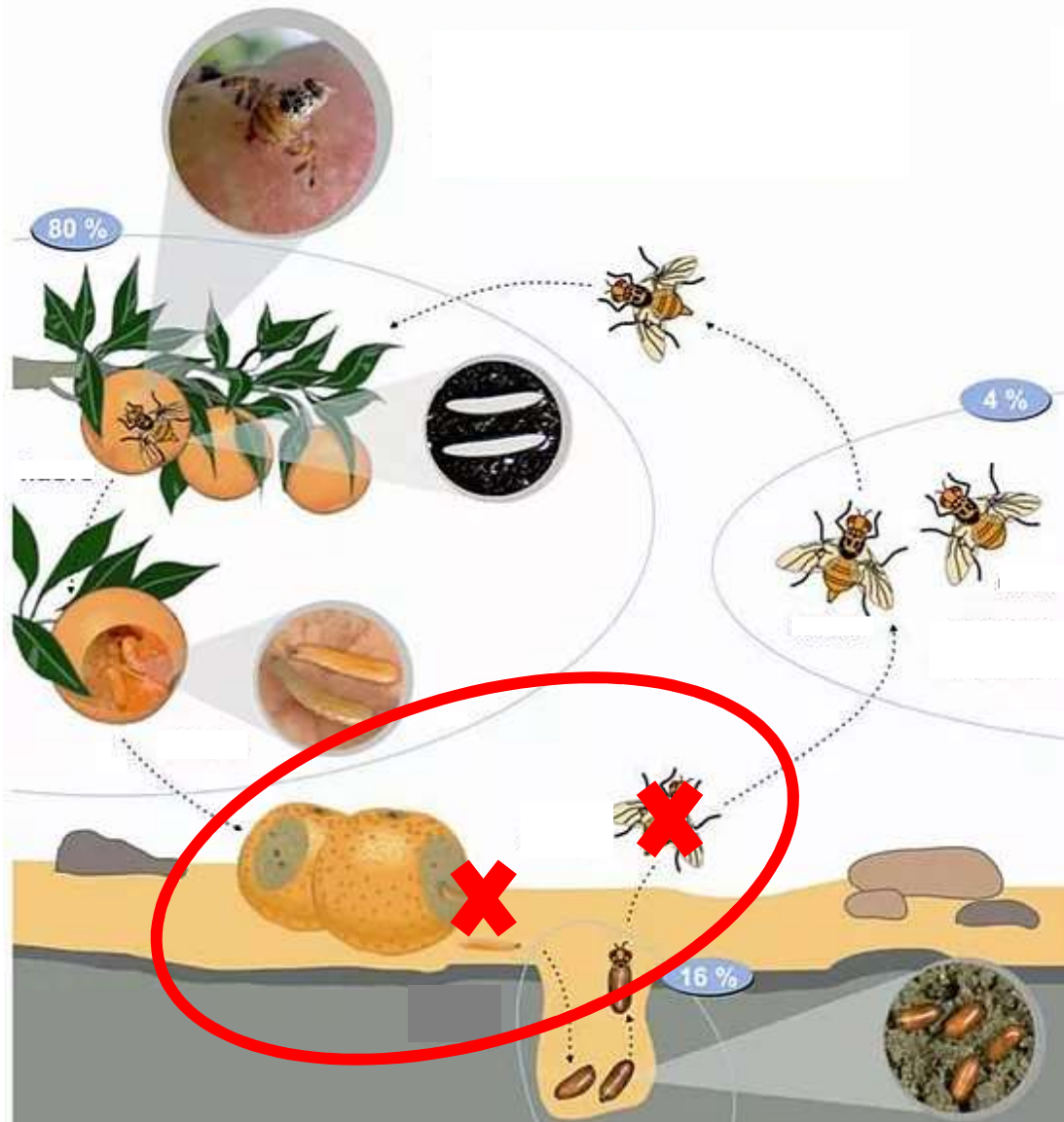
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FF-IPM Fruit Flies In-silico
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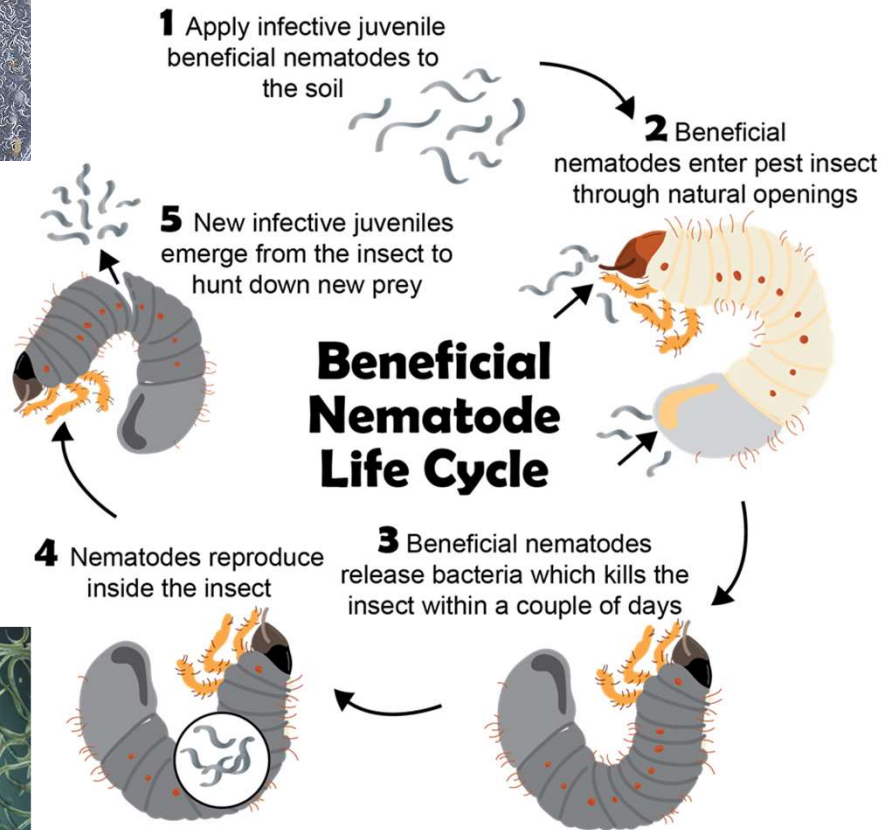
Life cycle of medfly and how entomopathogens fit in management



Damage/infestation by *Ceratitis capitata*



Entomopathogenic nematodes (EPN)



- ✓ Sensitive to UV
- ✓ Applied mostly in the soil
- ✓ Need humidity/soil moisture
- ✓ Temperature extremes
- ✓ A suite of species commercially available

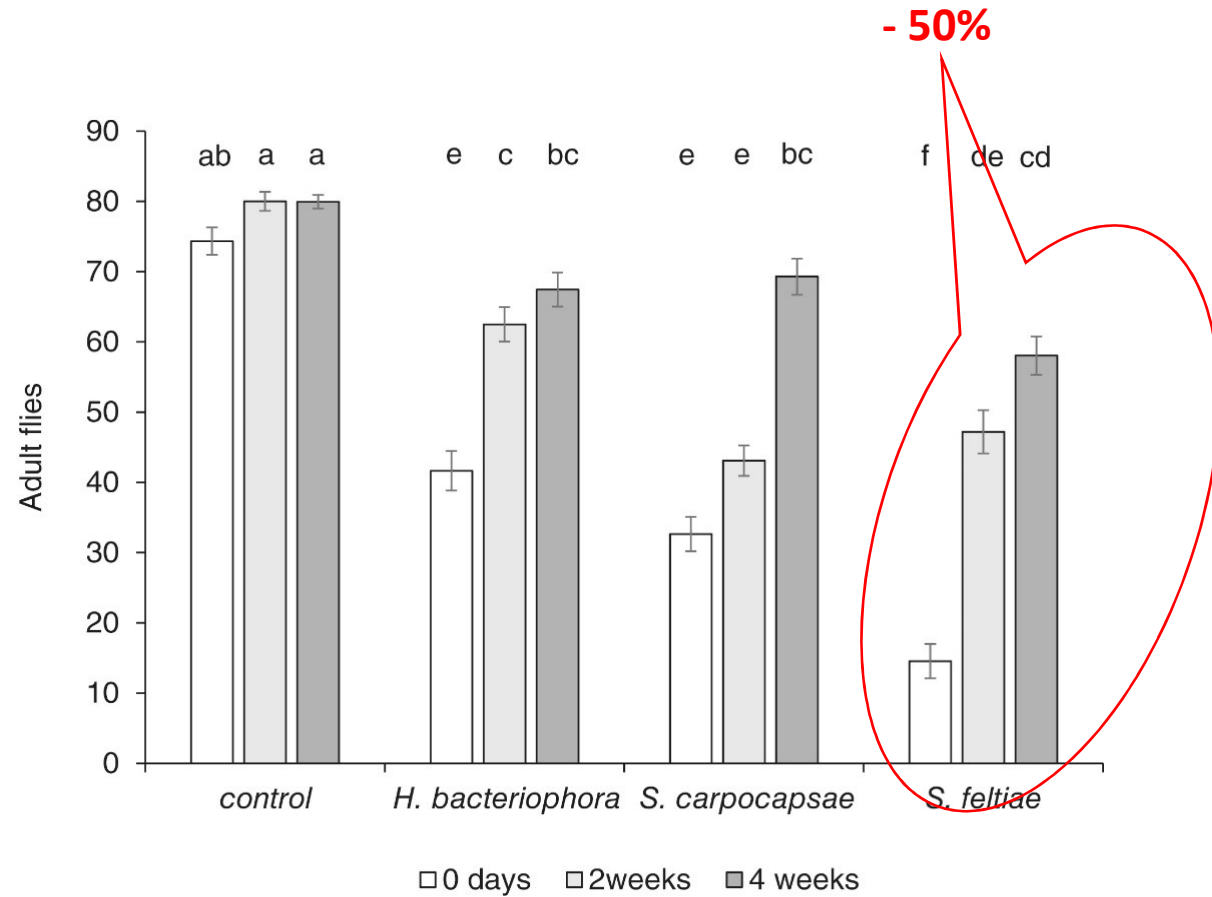
Biological control of medfly with entomopathogenic nematodes

- High efficacy, mostly studied in the laboratory
- Larvae are susceptible, pupae mostly not (small window of time)
- Local species/strains (limited availability)
- Cost of repeated applications as season progresses
- Efficacy of nematodes as season progresses (high temperatures/soil moisture/irrigation)
- Low/non-existent adaptation by farmers
- Alternative strategies sought after (application of nematodes **off-season/early season** to suppress initial population of emerging medfly adults from overwintering local populations)

Step 1. screen commercial EPN species efficacy/ residual activity



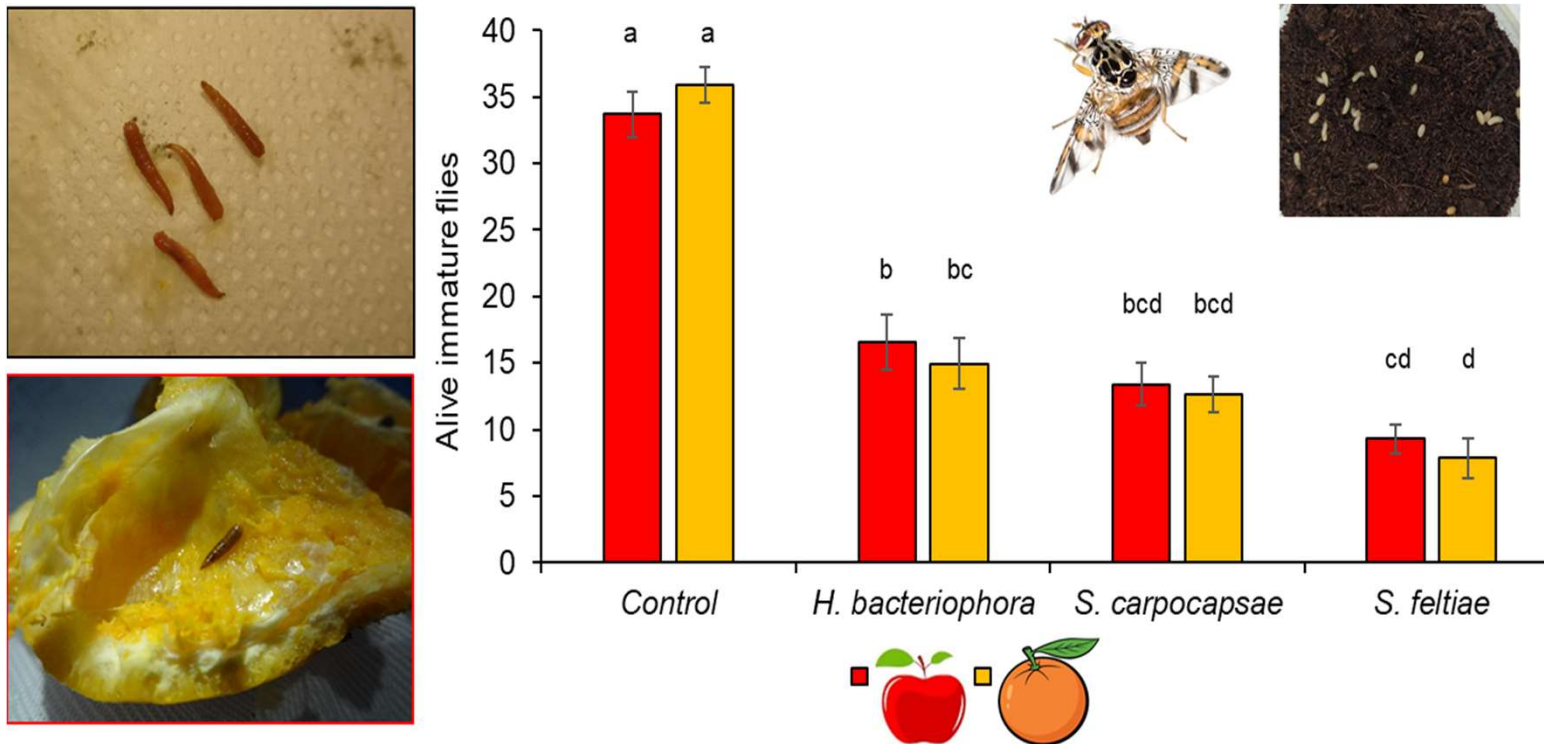
20°C, ~50% RH



Step 1. screen commercial EPN species efficacy at different temperature/dose regimes

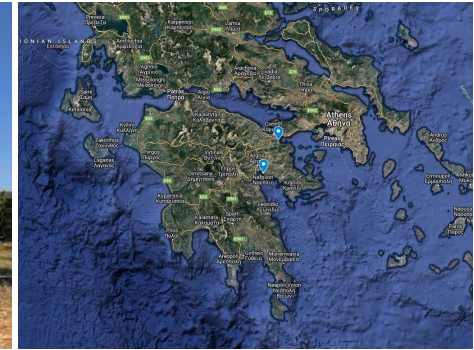
- ✓ *S. feltiae* most effective
- ✓ *H. downesi* not any better
- ✓ Higher dose gives better control (but does it worth it?)
- ✓ Less flies in lower temperatures

Step 2. screen commercial EPN species ability to infest medflies inside fruits



20°C, ~50% RH

Step 4. screen *S. feltiae* efficacy in field trials



Early season: March 2021

Varieties Sour orange+Valencia

Low dose 1.5 mi/m²

Moderate dose 2.5 mi/m²

Off-season: October 2021

Variety Navellina

Moderate dose 2.5 mi/m²



Step 4. screen *S. feltiae* efficacy in field trials

SPRING 2021-early season

AUTUMN 2021-early season

Moderate dose 2.5milJ/m²

65% reduction

65% reduction

Low dose 1.5milJ/m²

50% reduction



Testing of EPN for medfly biocontrol in semi-field studies

- Application of 5 mi IJs/m² of *S. feltiae* (Mexican strain) resulted to 86% mortality of medflies in papaya trees in **Hawaii** (Lindegren et al. 1990)
- The use of 25,000 IJs/m² of *Heterorhabditis baujardi* LPP7 in guava trees in **Brazil** led to significant mortality of medfly mature larvae >87% (Minas et al. 2016)
- *Heterorhabditis indica* IBCB n5 strain applied in doses of 10,000 and 100,000 IJs/m² resulted to 66 and 93% medfly larvae mortality, respectively in guava trees in **Brazil** (Dolinski 2016)

Costs of early or off-season EPN application in citrus



- Considering an average of 350 trees per ha (around 300 to 400 trees per ha), area to be treated per ha is around 2450 m² per ha (7 m² / tree)
- Costs of sanitation measures for orchards, taking Italy as an example, were estimated at almost 700 euros per ha
- Off-season application might target not the entire orchards but defined hot spots and therefore reducing substantial the treatment cost (requires further experimentation)

Scenarios		Once per season		Twice per season	
		Low dose	Moderate dose	Low dose	Moderate dose
Nematodes	Materials Cost (0.2€ per million)	0.2	0.2	0.2	0.2
	Quantity of nematodes per m ² (in millions)	1.5	2.5	1.5	2.5
	m ² to treat per ha	2450	2450	2450	2450
	quantity EPN per ha	3,675	6,125	3,675	6,125
	Costs/ha	735	1,225	1,470	2,450
Labour	Labour hours per ha	30	30	30	30
	Labour cost (€/h)	8.5	8.5	8.5	8.5
	Labour costs	255	255	510	510
TOTAL COSTS/HA		990	1,480	1,980	2,960

What can be further improved/evaluated



- Use of adjuvants (wetting agents, low cost)?
- Combinations of nematodes?
- Application schemes (single vs. double)
- Application (irrigation/sprayers/formulations)
- Costs of nematodes: price is linked to the market size and could easily drop from 0.2 to 0.1€/million IJs.
- Compatibility with other tools (mass trapping, ground predators, pesticides)



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