UNIVERSITY OF COPENHAGEN FACULTY OF LIFE SCIENCES

Department of Agriculture and Ecology

Distribution, Abundance and Diversity of Fungal Entomopathogens:

Foundations for Conservation Biological Control

Nicolai V. Meyling

nvm[a]life.ku.dk

ICROFS

Conservation Biological Control (CBC) - definitions

"Modifications of the environment or existing practices to protect and enhance specific natural enemies or other organisms to reduce the effects of pests"

Eilenberg *et al.* (2001). *BioControl*, 46: 387-400

- No introductions !
- How do practices affect natural enemy community?

- CBC: Much focus on arthropods
- What about the microbes?

What do we need to know?

- Naturally occurring fungi
- Abundance and distribution
- Host range – specialist or generalist?
- Diversity – how to evaluate?
- Below- and aboveground interactions
- Fungi as integrated part of the natural enemy community

When knowledge is obtained, then evaluate management practices

Examples from temperate Europe (Denmark)

Natural occurrence of fungal entomopathogens

- Microbes are ”invisible”
- Entomophthoralean fungi create visible epizootics
- Hypocrealean (Ascomycota) fungi less visible effects
- Soil environment as reservoir
- How is this reservoir affected by management practices?

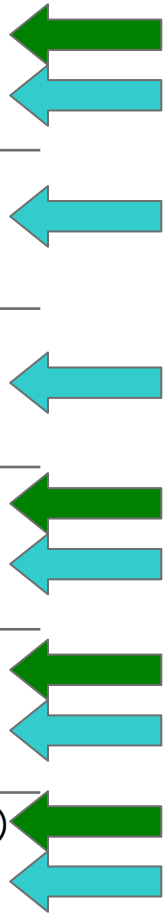
Metarhizium anisopliae

Beauveria bassiana

Isaria fumosorosea

Compiling data of occurrence from several sites characterized by habitat

Country	Reference
Denmark 55°N	Steenberg (1995)
Finland 62°N	Vänninen (1995)
UK 52°N	Chandler et al. (1997)
Canada 45°N	Bidochka et al. (1998)
China 40°N	Sun et al. (2008)
Spain 40°N	Quesada-Moraga et al. (2007)
South Africa 33°S	Goble et al. (2010)



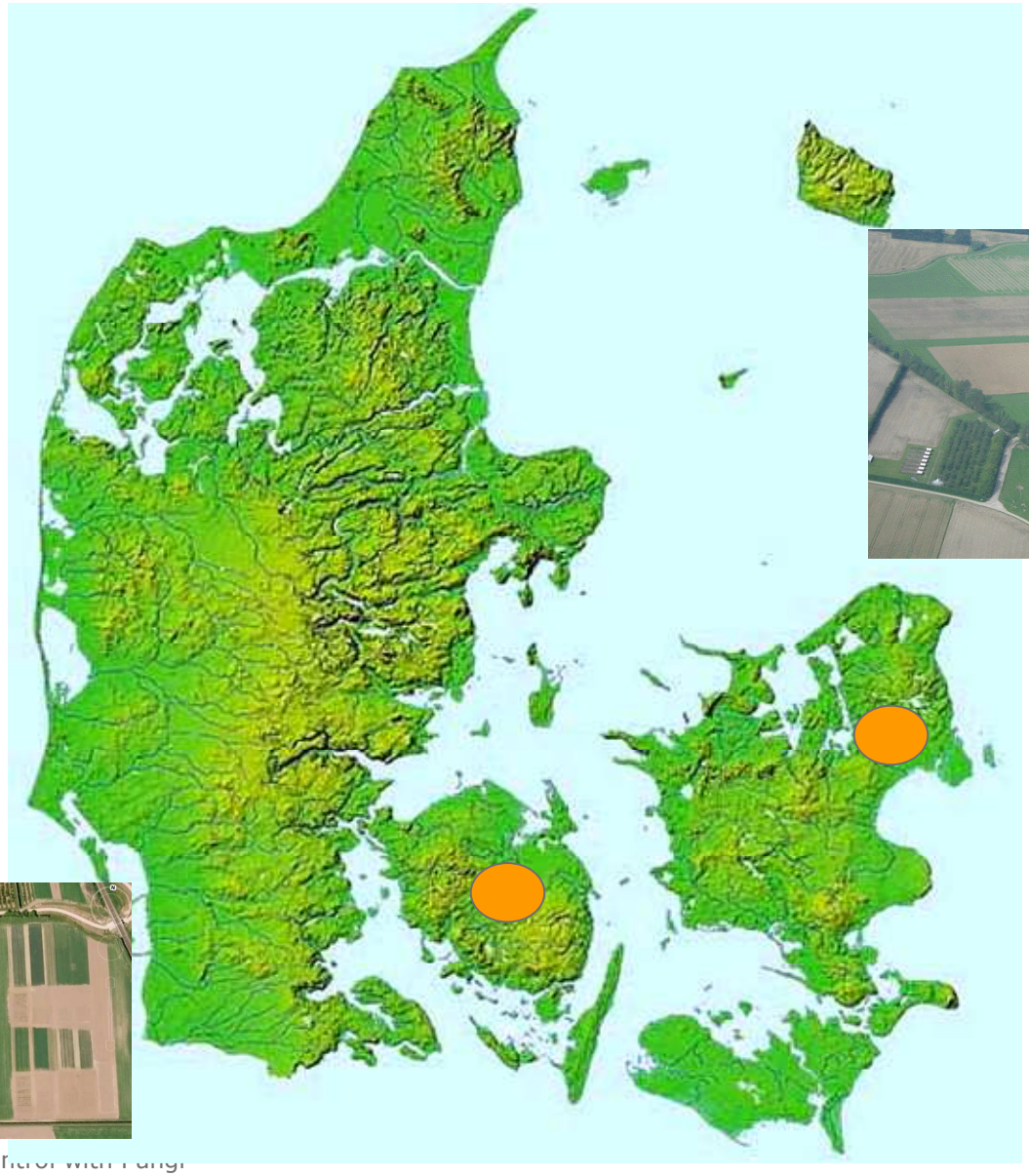
Metarhizium anisopliae most abundant in cultivated soil

Beauveria bassiana most abundant in "natural" soil

Can we generalize?

- from region to site?

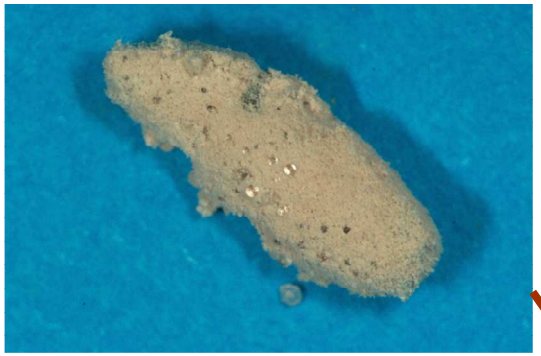
Locality specific abundance and distribution: Denmark



Taastrup
(Bakkegården)

Årslev

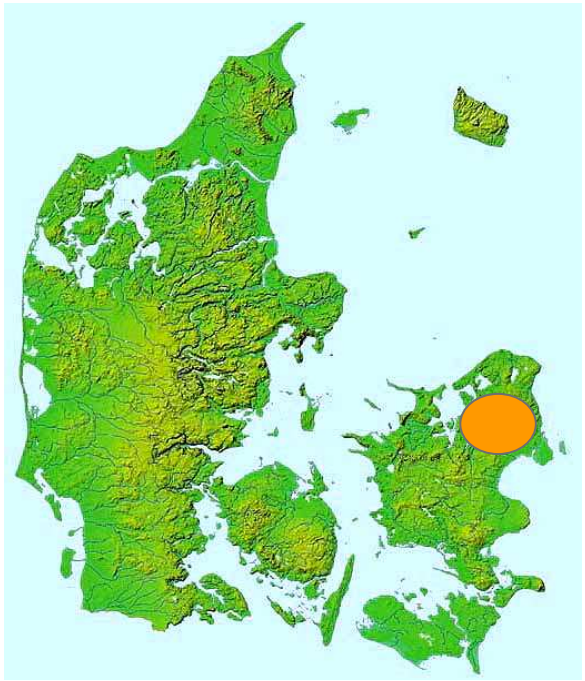
Occurrence in soil: *Galleria*-bait method



Isaria fumosorosea

- in hedgerows

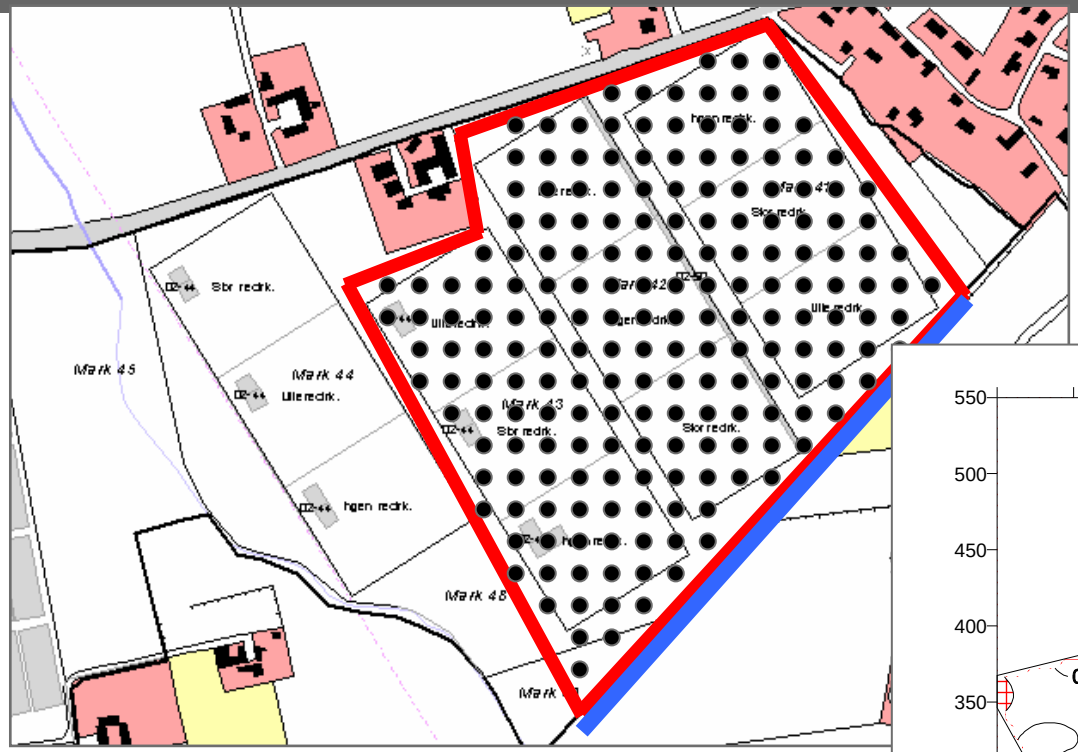
Metarhizium anisopliae



Beauveria bassiana

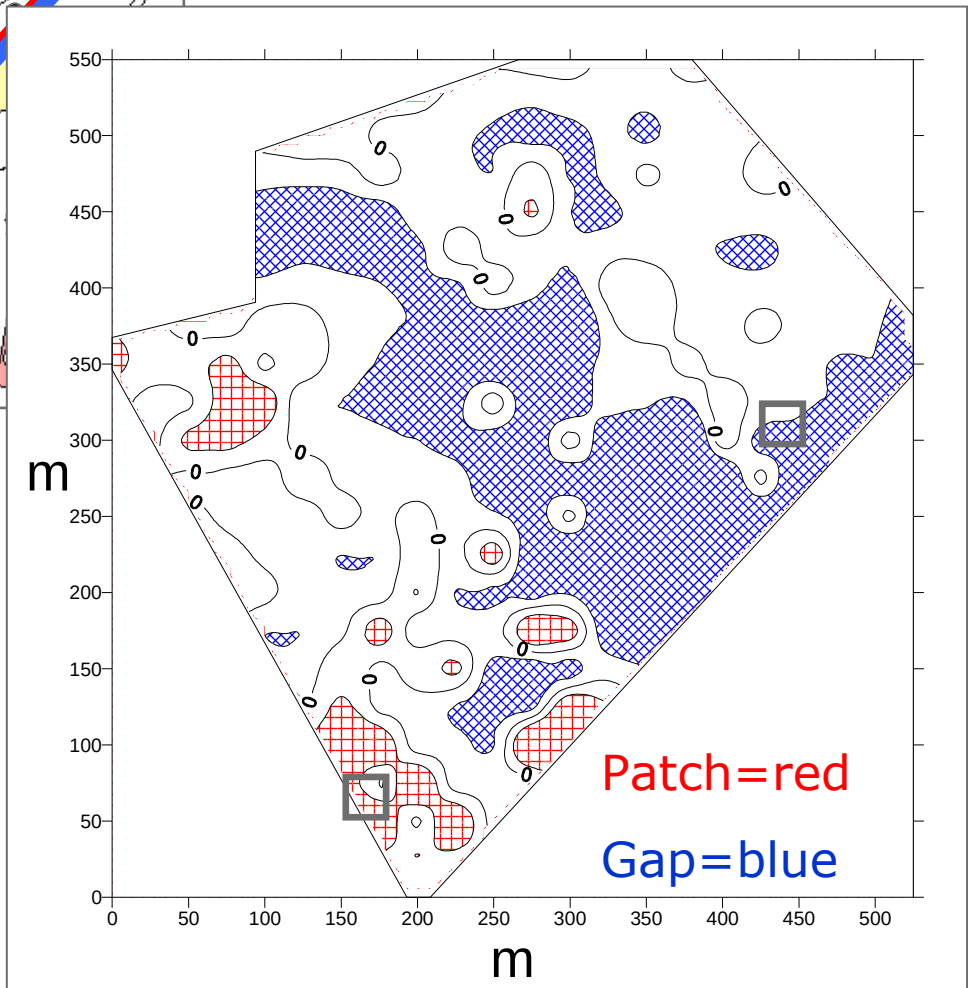
Most frequent

Meyling and Eilenberg (2006) *Agriculture, Ecosystem and Environment*, 113, 336-341



GIS coordinates (n=274)

Location by GPS

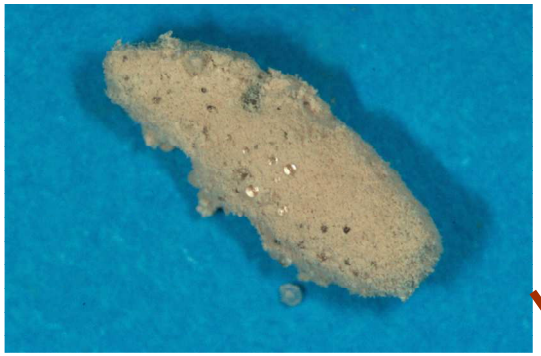


Spatial statistics for *Beauveria bassiana*:

Significant clustering

Meyling and Eilenberg (2006) *Agriculture, Ecosystem and Environment*, 113, 336-341

At another site: different abundance patterns



Isaria fumosorosea

- in hedgerows

Most frequent

Metarhizium anisopliae

Beauveria bassiana

Meyling et al. (in prep.)

Conventional and organic vegetable crops

Metarhizium anisopliae in soil 2007-2008

Two types of management practices:

1. Conventional vs. Organic
2. Perenial herbs between crop rows

Meyling et al. (in prep.)

Effect of farming system on occurrence of *Metarhizium anisopliae* in the soil

- No difference between conventional and organic
- Reduced occurrence of *M. anisopliae* in perenial herbs
- Marginally higher taxon diversity in perenial herbs

Meyling et al. (in prep.)

Below- and aboveground interactions

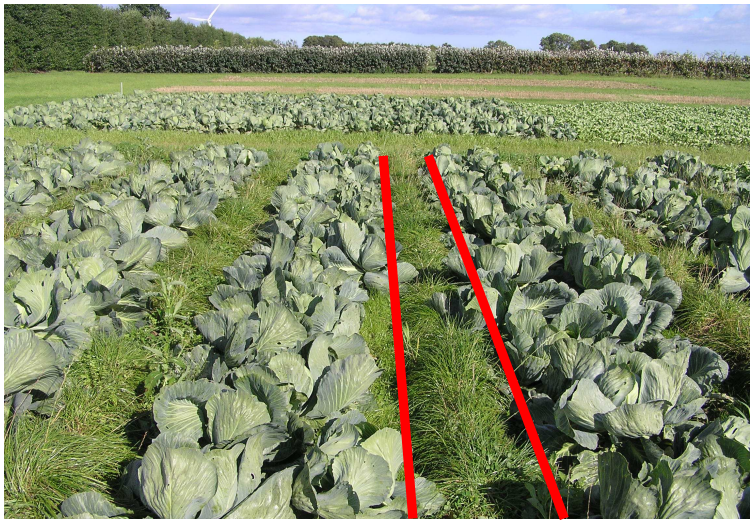
CBC: the fungus must infect the target pest

- Spatial location of fungus and pest
- Which fungi infects the pest in the field?

Assessment

- Evidence for below- and aboveground interactions?
- Site specific interactions:
  - ➢ reservoir in soil and arthropods aboveground

Below- and aboveground distribution of fungi



- Collections of mycosed arthropods on soil surface
- Similar plots as soil collections
- Is the reservoir of fungi in soil likely to contribute to host mortality aboveground?

Meyling et al. (in prep.)

Below- and aboveground distribution of fungi

Meyling et al. (in prep.)

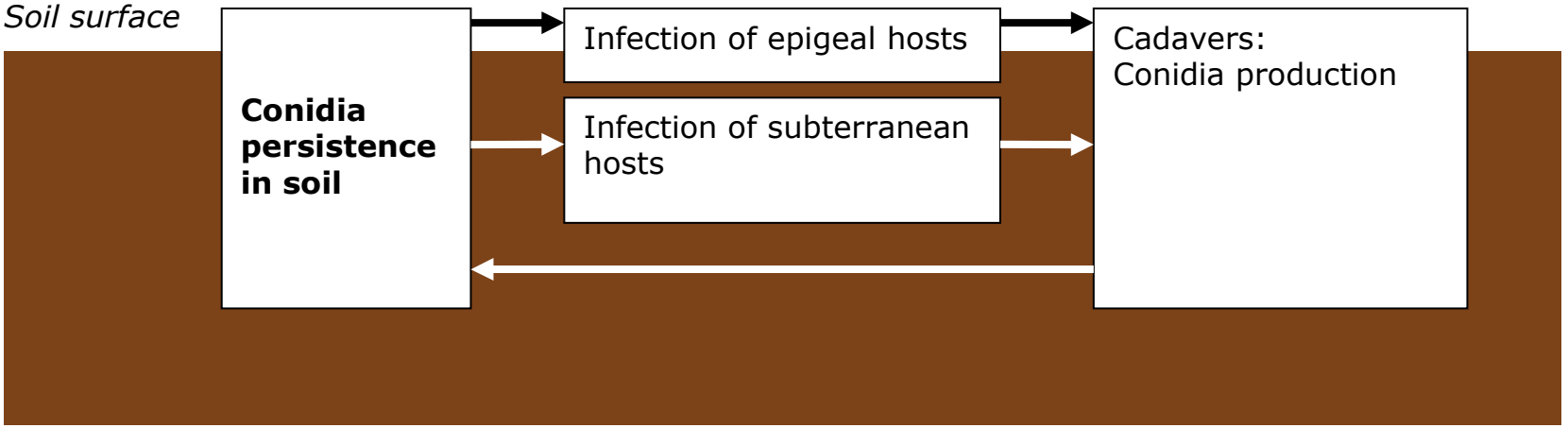
Metarhizium anisopliae dynamics

-No aboveground cycling?

-System specific?

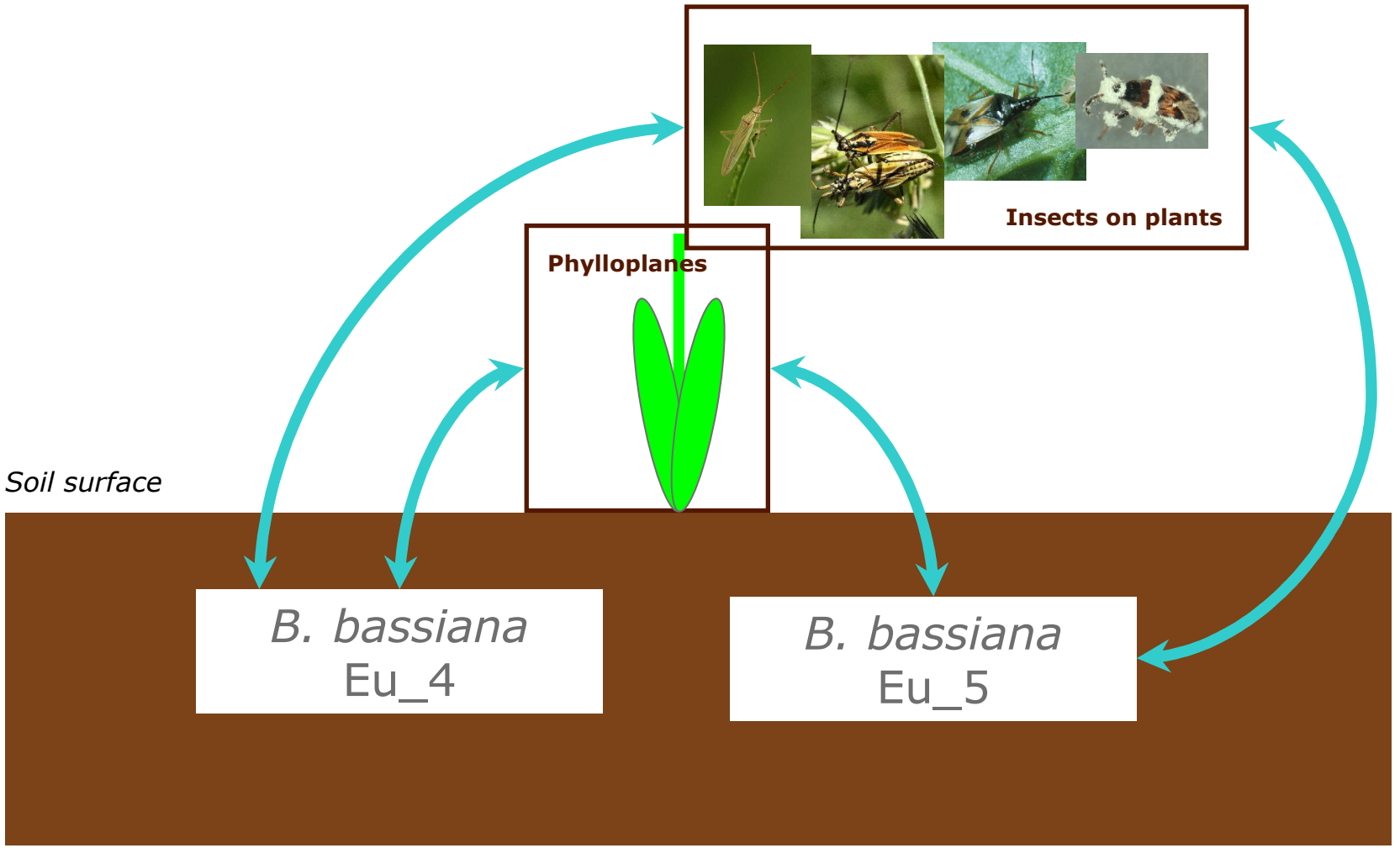
-Knowledge of local community

-CBC: *M. anisopliae* targeting soil dwelling pests



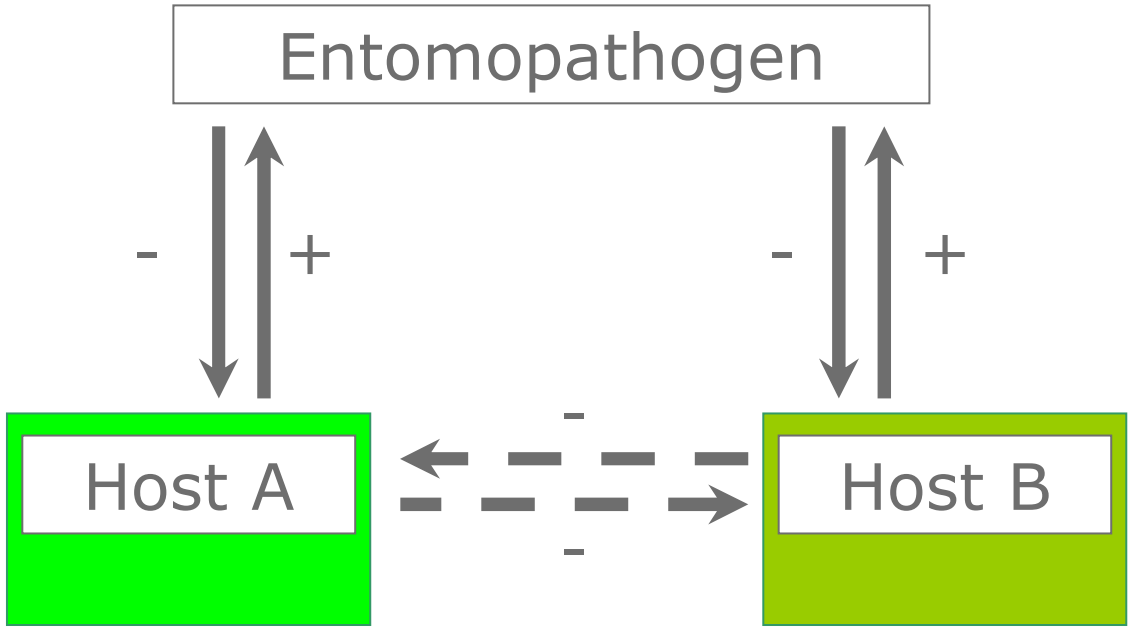
Meyling & Eilenberg (2007). *Biological Control* 43: 145-155

Beauveria bassiana dynamics



Based on Meyling *et al.* (2009) *Molecular Ecology*, 18, 1282-1293

Ecological principles: Shared natural enemies - indirect effects



Apparent competition - DMIE

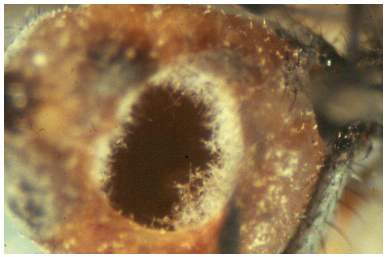
- Shared fungal entomopathogens?

Meyling & Hajek (2010). *BioControl* 55: 39-54

Host range and specialization

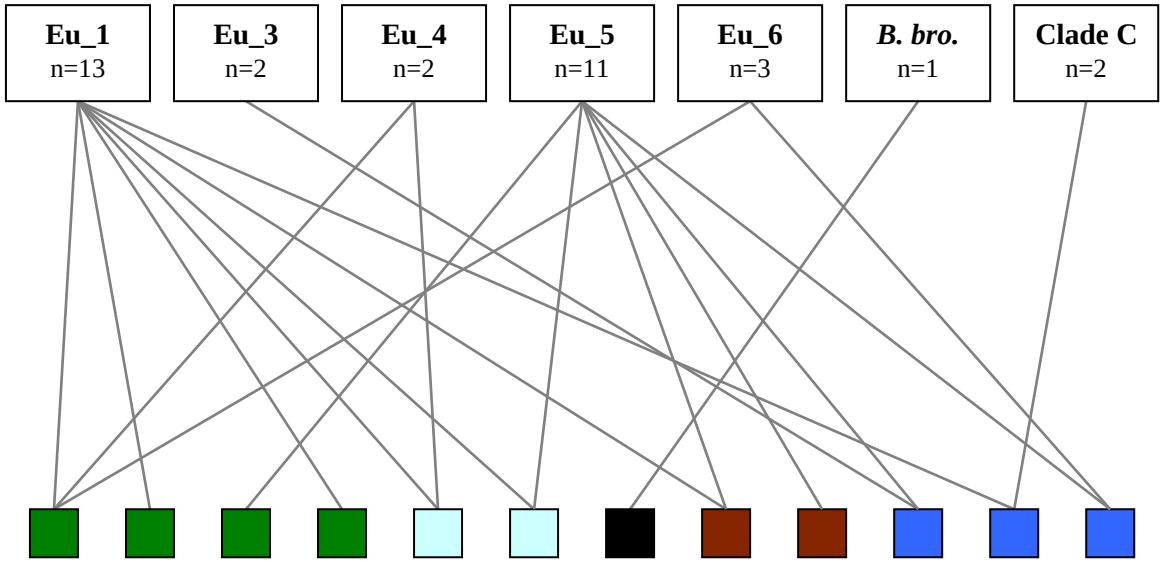
Strongwellsea spp. *Pandora neoaphidis* *Beauveria brongniartii* *Beauveria bassiana*

Specialist *Generalist*




Ecological host range – observe infections in the field

Host range of *Beauveria* spp. at a single site

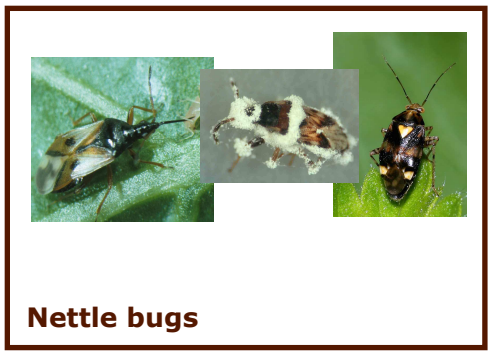



Grass bugs and beetles


Ground beetle


Hawthorn bug and beetle


Anthomyiid flies


Nettle bugs

Meyling *et al.* (2009) *Molecular Ecology*, 18, 1282-1293

Fungal entomopathogens are only one group of natural enemies of pests

Natural enemy community:
Predators, parasitoids and pathogens

What should be predicted from multiple enemies?

1. Negative effects - conflicting
2. Neutral effects – compatible
3. Positive effects - complementarity

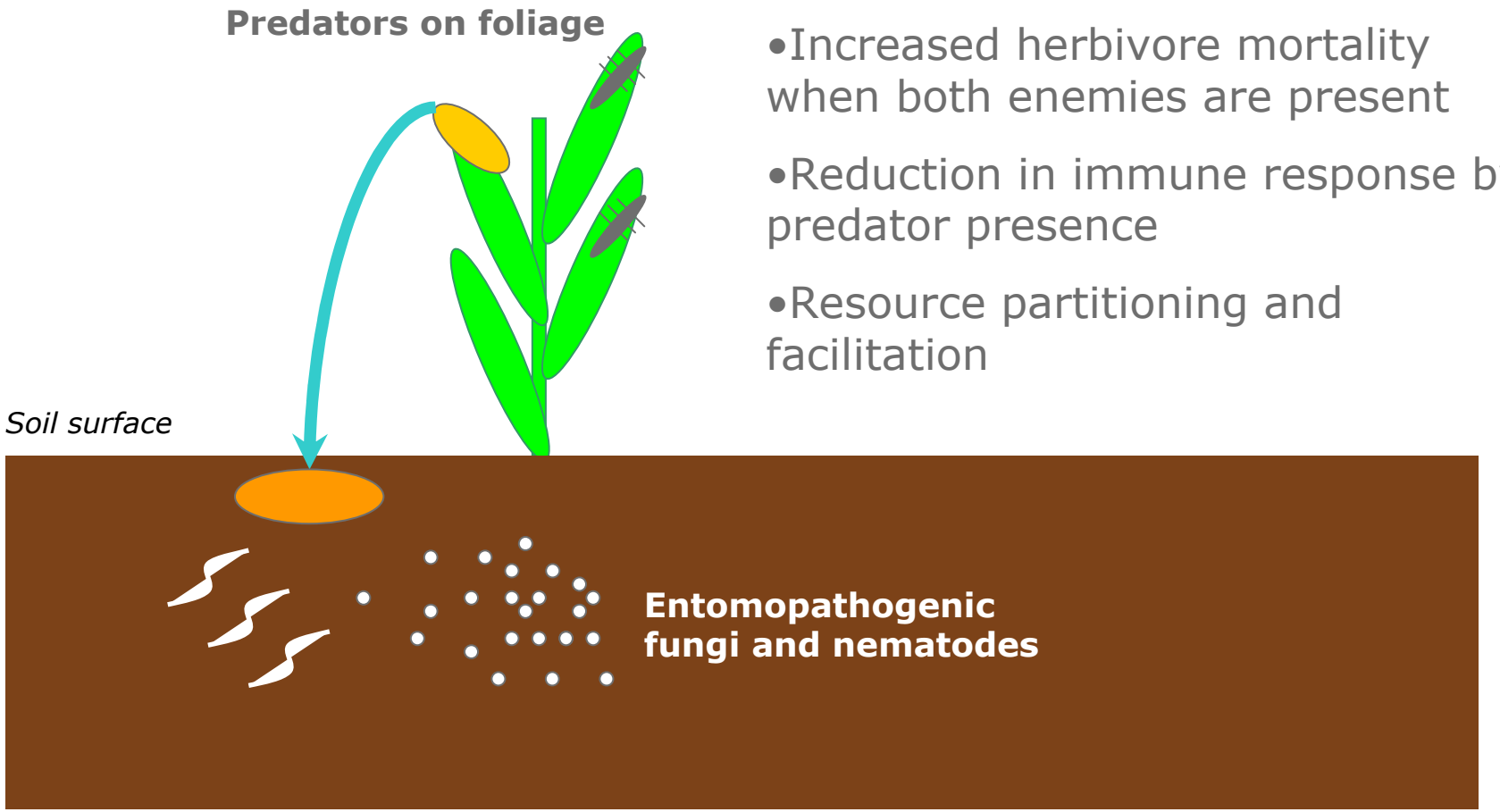
Complementarity – ecological differences

- Resource partitioning – additive effect
- Facilitation – synergistic effect

Straub *et al.* (2008) *Biological Control* 45: 225-237

Considering fungal entomopathogens in multitrophic context

Niche complimentarity: Predators and pathogens of Colorado Potato Beetle



- Increased herbivore mortality when both enemies are present
- Reduction in immune response by predator presence
- Resource partitioning and facilitation

Based on Ramirez & Snyder (2009) *Ecology*, 90, 2832-2839

CBC with fungal entomopathogens – future perspectives?

Why do particular fungal taxa occur in specific habitats?

- Dispersal potentials and mechanisms
- Diversity and host range
  - Molecular methods
- Interactions with other natural enemies
  - Context dependent – consider pest life cycles

Effects of management practices on the above
  - practices targeting arthropods

Ecological knowledge is essential to CBC

Thanks

Tariq Butt, Michael Brownbridge

Jørgen Eilenberg, Stephen Rehner