Distribution patterns of fungal entomopathogens in soil habitats:

Natural occurrence, diversity, dynamics

Nicolai V. Meyling

ICROFS

Assessing diversity in soils

- Isolation methods

Patterns of distribution

- Agricultural vs. natural habitats
- Horizontal distribution

Dynamics of soil reservoir

- Cycling between below and above ground environments

Molecular characterization

- Species identification
- Emergent patterns and implications

Natural occurrence on fungal entomopathogens in soil habitats – why ?

Reservoir and buffer environment

- **Natural enemies – targets for conservation biological control strategies**
- **Effects of management practices on fungal populations**
- **Find indigenous isolates for biological control**
- **Predict effects of augmented biocontrol strains**

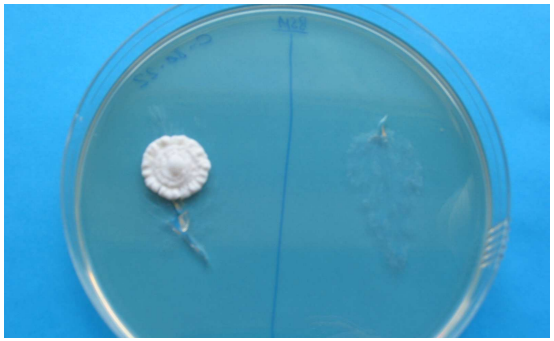
Isolation from soil environment

Insect bait methods

- Entomopathogenic isolates
- Standardized approach?
- Which insects?

Selective *in vitro* media

- Detection levels?
- How selective?

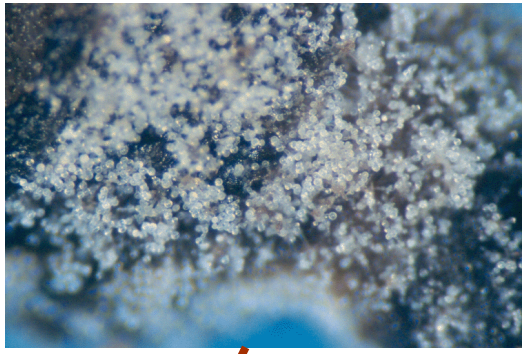


"… the Galleria *bait method tends to be more sensitive that the* (in vitro) *isolation method."*

From Keller *et al.* (2003) *BioControl*, 48, 307-319

Isaria fumosorosea

Conidiobolus coronatus

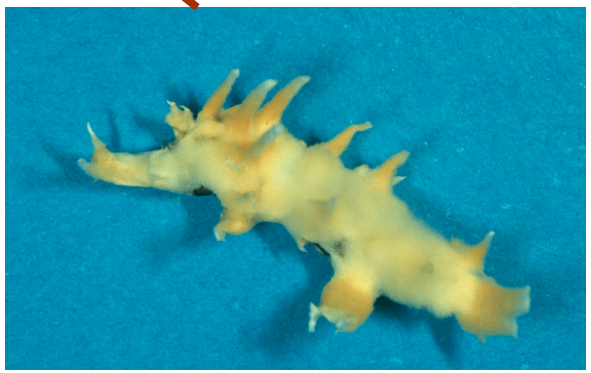


Metarhizium anisopliae

Metarhizium flavoviride

Beauveria bassiana

Hirsutella nodulosa

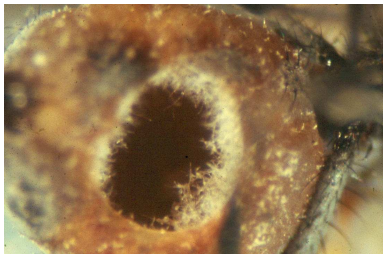


Isaria farinosa

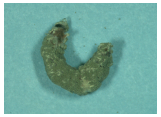
Host range and specialization

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

Specialist *Generalist*




Host range: using the target pest

		Tolypocladium cylindrosporum	*Metarhizium anisopliae* 	*Beauveria bassiana* 
Delia floralis (Diptera)		+	+	-
Galleria mellonella (Lepidoptera)		-	+	+

Based on Klingen *et al.* (2002) *Agriculture, Ecosystem and Envrionment*, 91, 191-198

Host range: baiting for Entomophthorales

	Cereal field	*Grass*	*Beneath Bird Cherry trees*
Pandora neoaphidis	++	+	+
Conidiobolus obscurus	+	+	+

Based on Nielsen *et al.* (2003) *Biological Control*, 28, 92-100

Temperature: baiting conditions

Habitat and Fungus	18°C	25°C
Forest soil		
M. anisopliae	0 %	7 %
B. bassiana	1 %	12 %
Agricultural field		
M. anisopliae	5 %	38 %
B. bassiana	53 %	10 %
Fallow field		
M. anisopliae	35 %	80 %
B. bassiana	18 %	0 %

Based on data from Mietkiewski and Tkaczuk (1998) *IOBC/WPRS Bulletin*, 21 (4), 41-44

Distribution of fungal entomopathogens: habitat associations

- Which species in which habitat?
- We define the habitats and characteristics
- We define the parameters –
  - are they important from the fungus point-of-view?
- Correlations = causation?

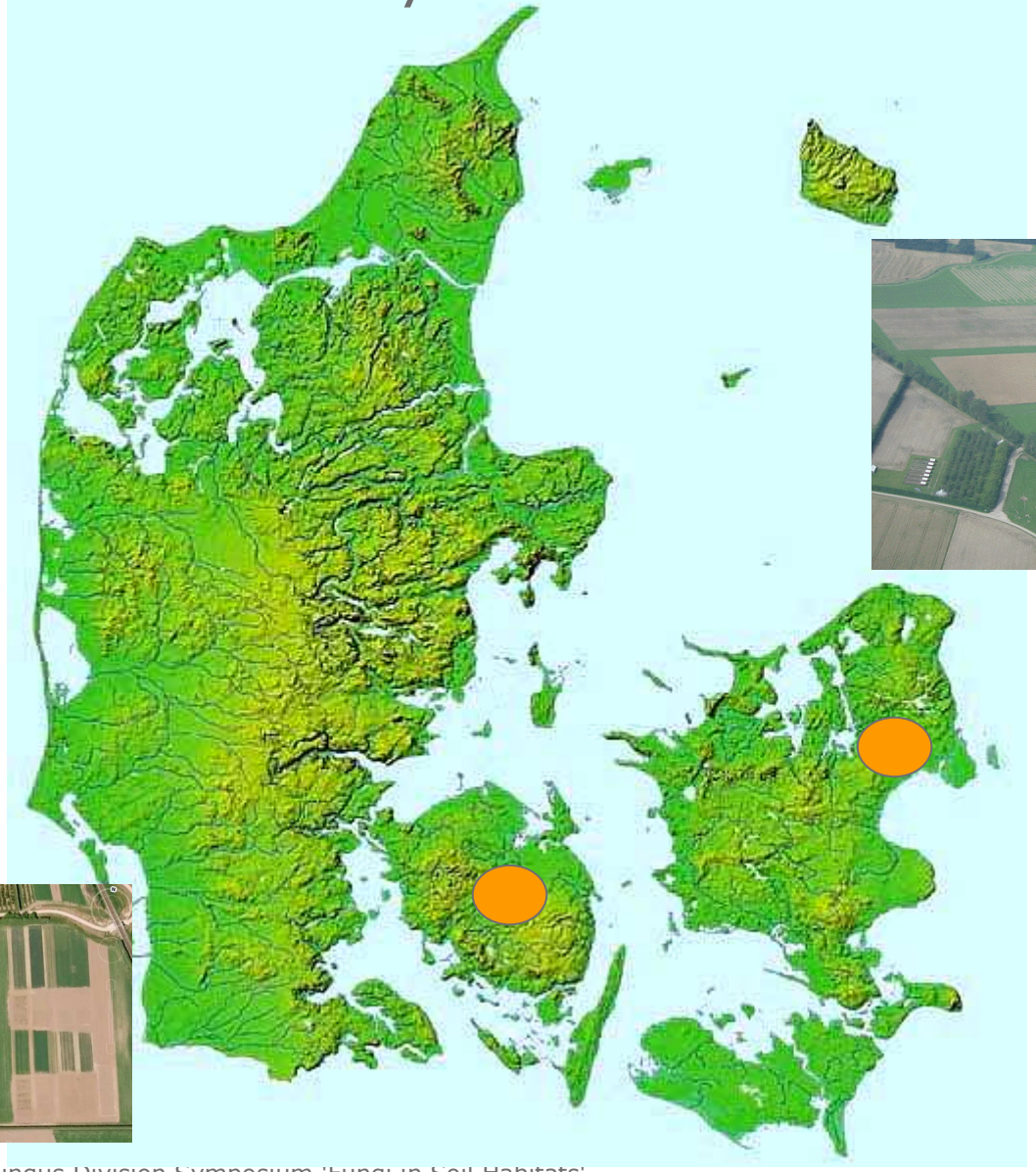
Frequency of occurrence (%)

Country	Fungus	Cultivated habitat	"Natural" habitat	Reference
Denmark 55°N	*B. bassiana*	**38.5**	**52.9**	Steenberg (1995)
	M. anisopliae	**51.3**	**7.8**	
	I. fumosorosea	**2.6**	**9.8**	
Finland 62°N	*B. bassiana*	**5.6**	**28.1**	Vänninen (1995)
	M. anisopliae	**14.9**	**24.2**	
	I. fumosorosea	**0.5**	**1.7**	
UK 52°N	*B. bassiana*	**1.0**	**7.7**	Chandler et al. (1997)
	M. anisopliae	**1.0**	**1.3**	
	I. fumosorosea	**0.0**	**3.3**	
Canada 45°N	*B. bassiana*	**~35**	**~65**	Bidochka et al. (1998)
	M. anisopliae	**~63**	**~36**	
China 40°N	*B. bassiana*	**27.4**	**86.3**	Sun et al. (2008)
	M. anisopliae	**60.0**	**26.4**	
	I. fumosorosea	**15.6**	**37.5**	
Spain 40°N	*B. bassiana*	**~34**	**~53**	Quesada-Moraga et al. (2007)
	M. anisopliae	**~10**	**~4**	

Habitat associations: regional scales

- ”Natural” habitats
  - *B. bassiana* and *I. fumosorosea*
- Agricultural fields
  - *M. anisopliae*
- Many ”similar” habitats sampled
  - Comparability assumed
- Generalizations from regional scales?
  - Local scale diversity?

Locality specific diversity and distribution: Denmark

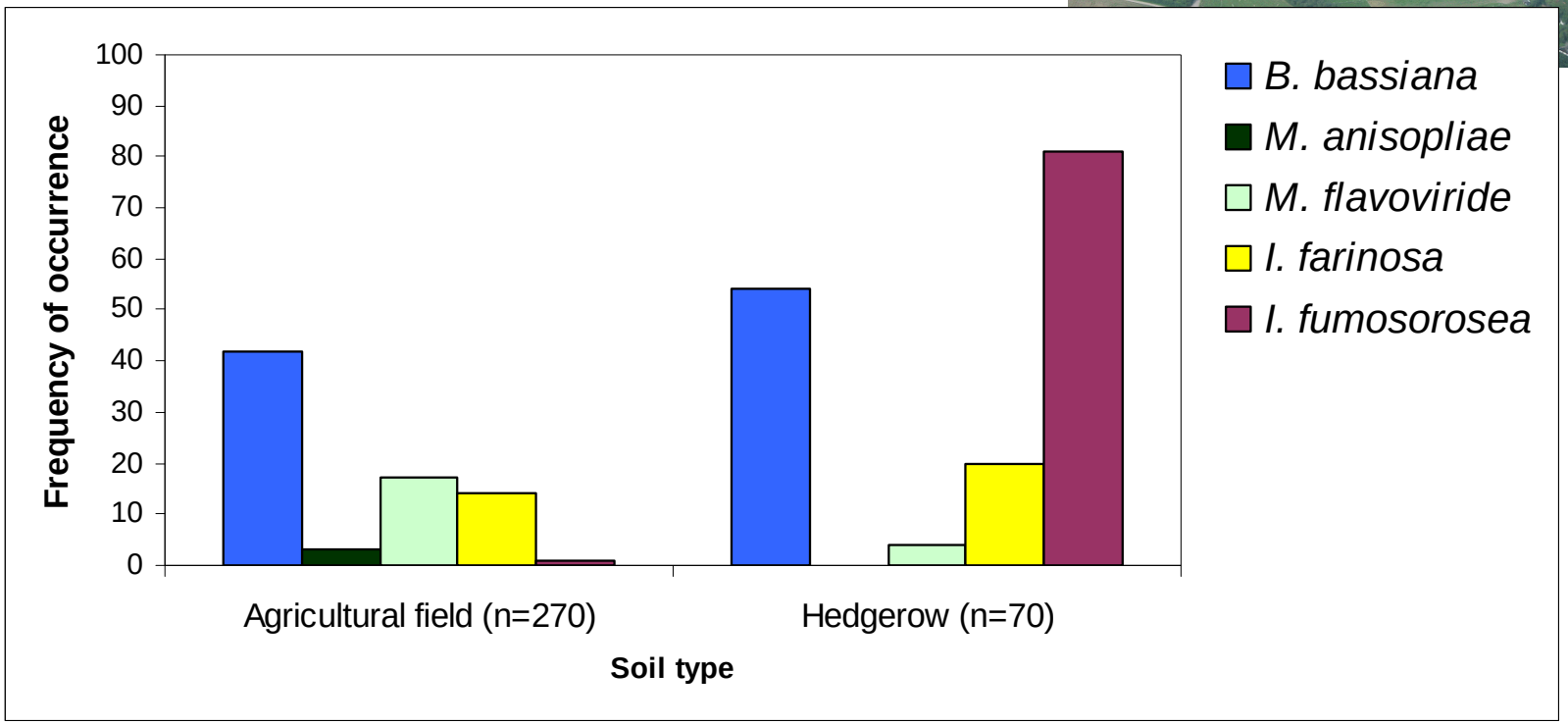


Taastrup
(Bakkegården)

Årslev

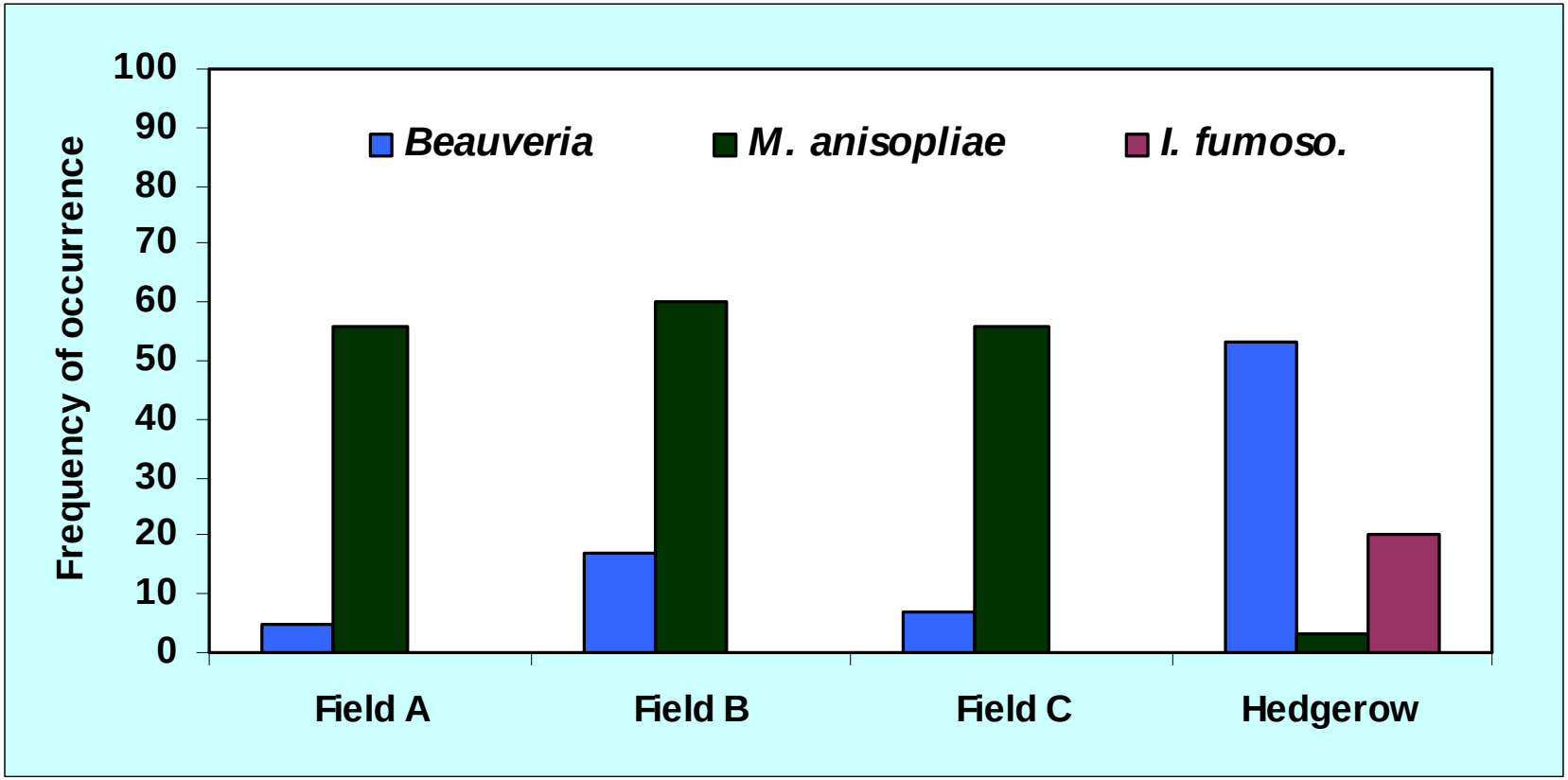
Taastrup, Bakkegården 2002

B. bassiana dominating in field



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

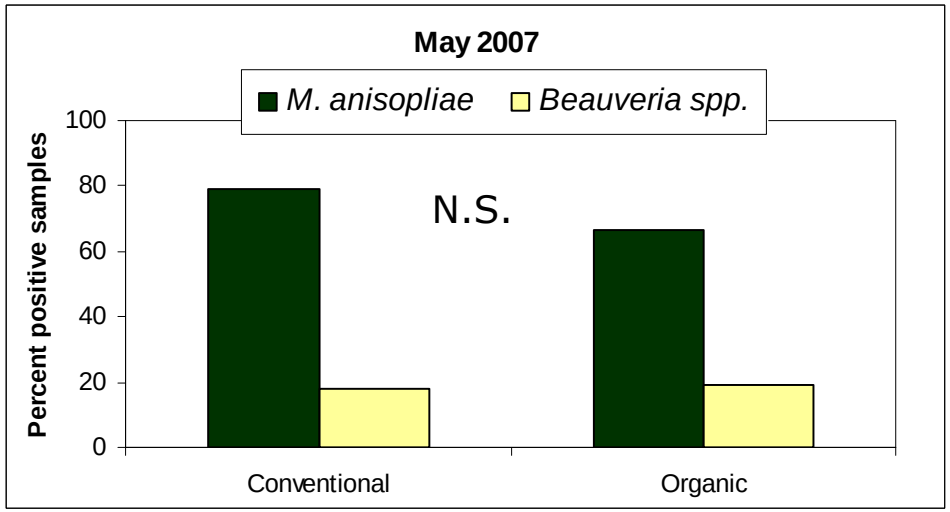
Årslev 2006

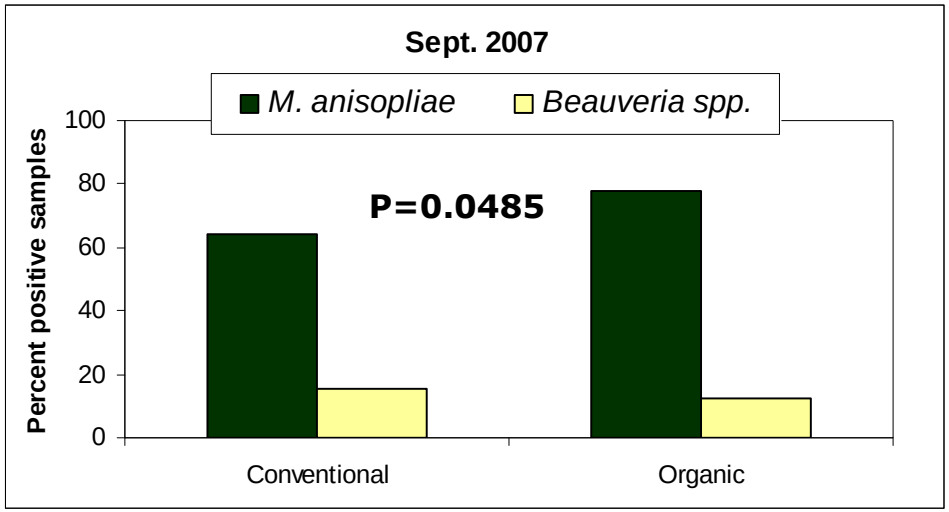


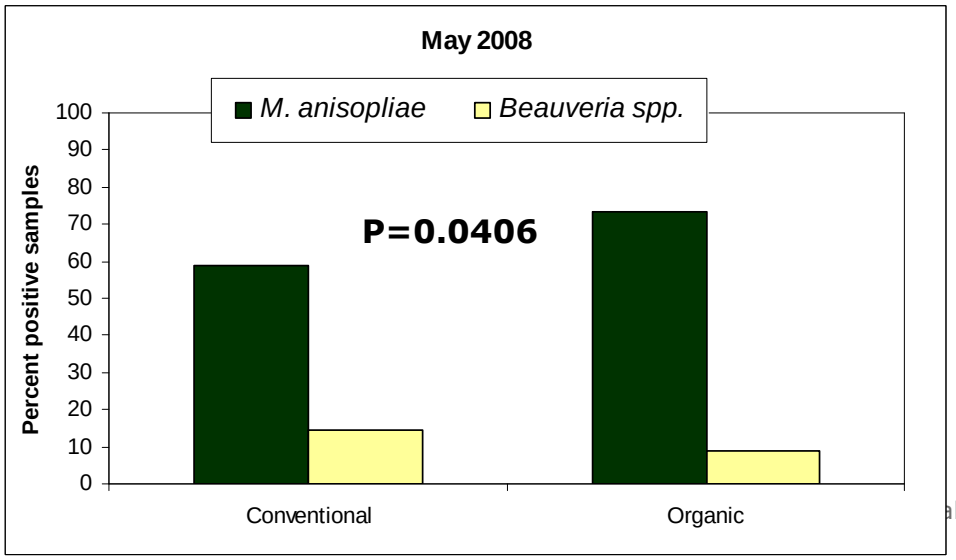
Unpublished data

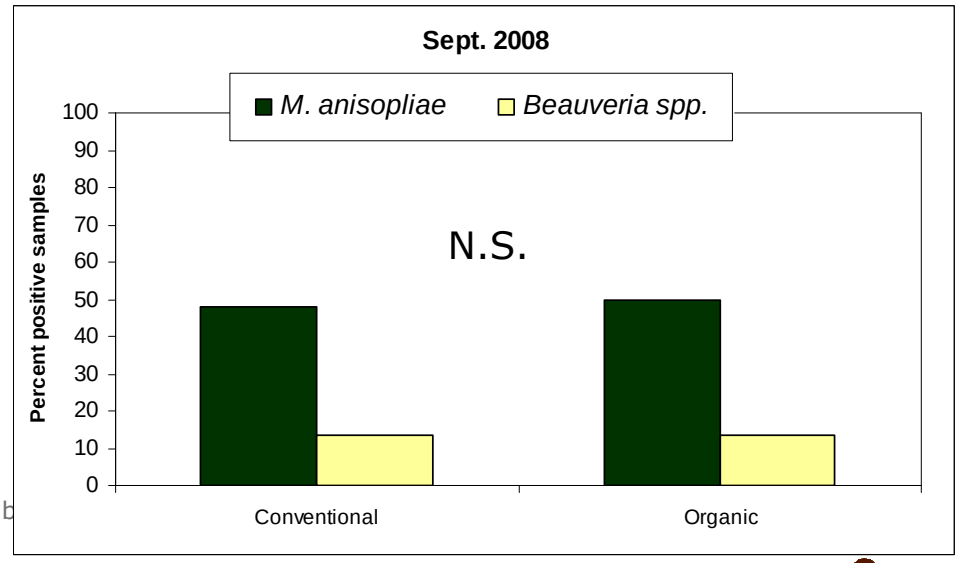
M. anisopliae dominating in field

Agricultural practices: conventional vs. organic (Årslev)





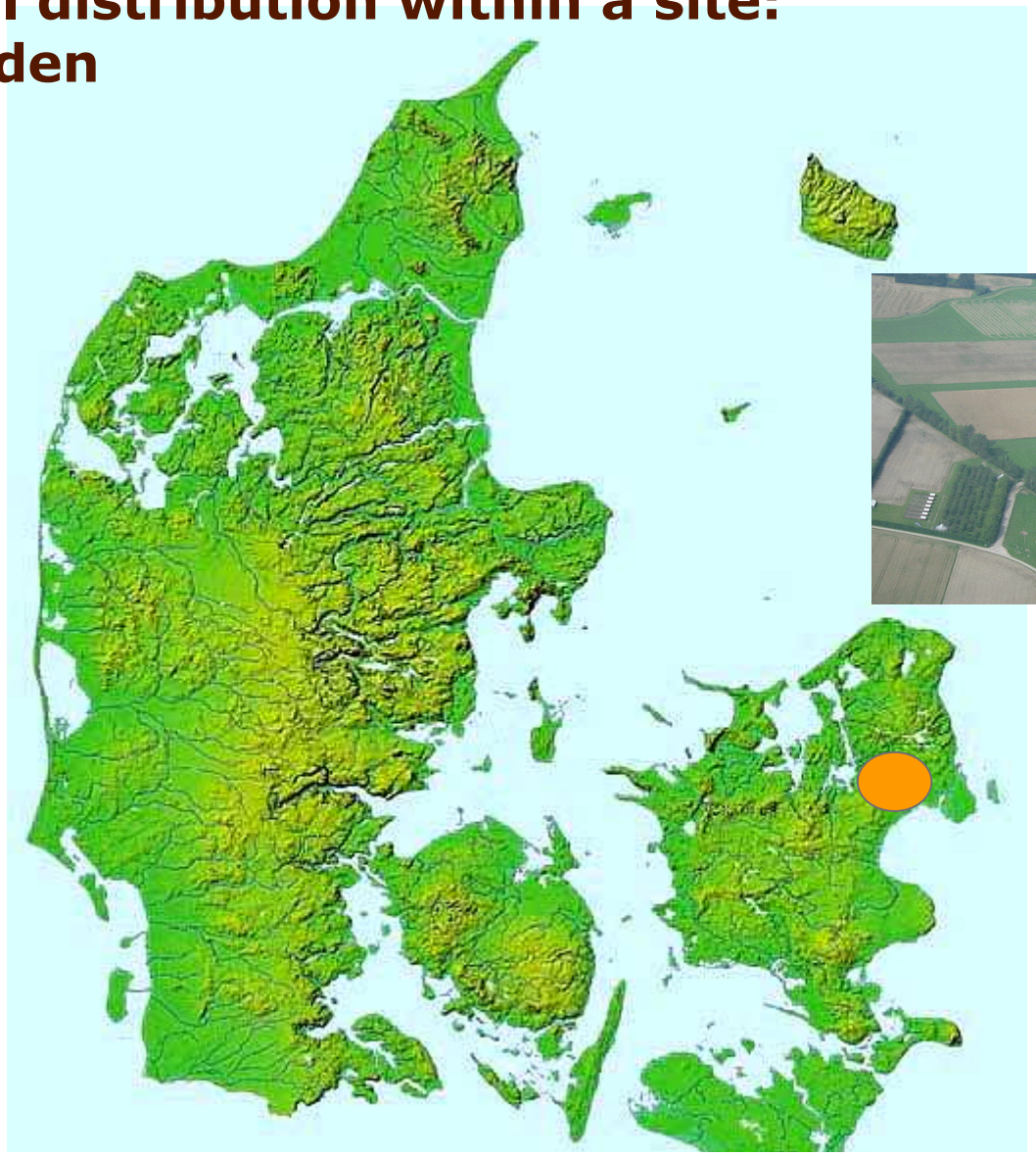




Horizontal distribution within a site

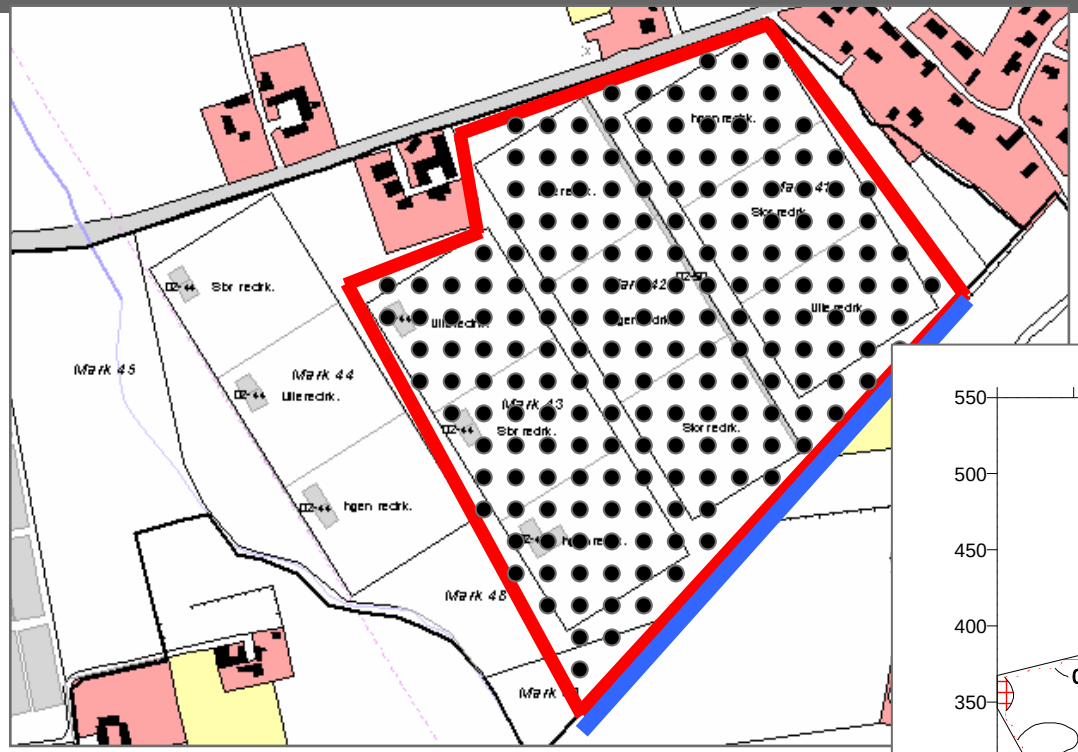
- Where to sample ?
- Identification of patches
- Size of patches: distance between samples
- When do we have enough samples ?
- Patch dynamics ?

Horizontal distribution within a site: Bakkegården



Taastrup
(Bakkegården)

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



GIS coordinates (n=274)

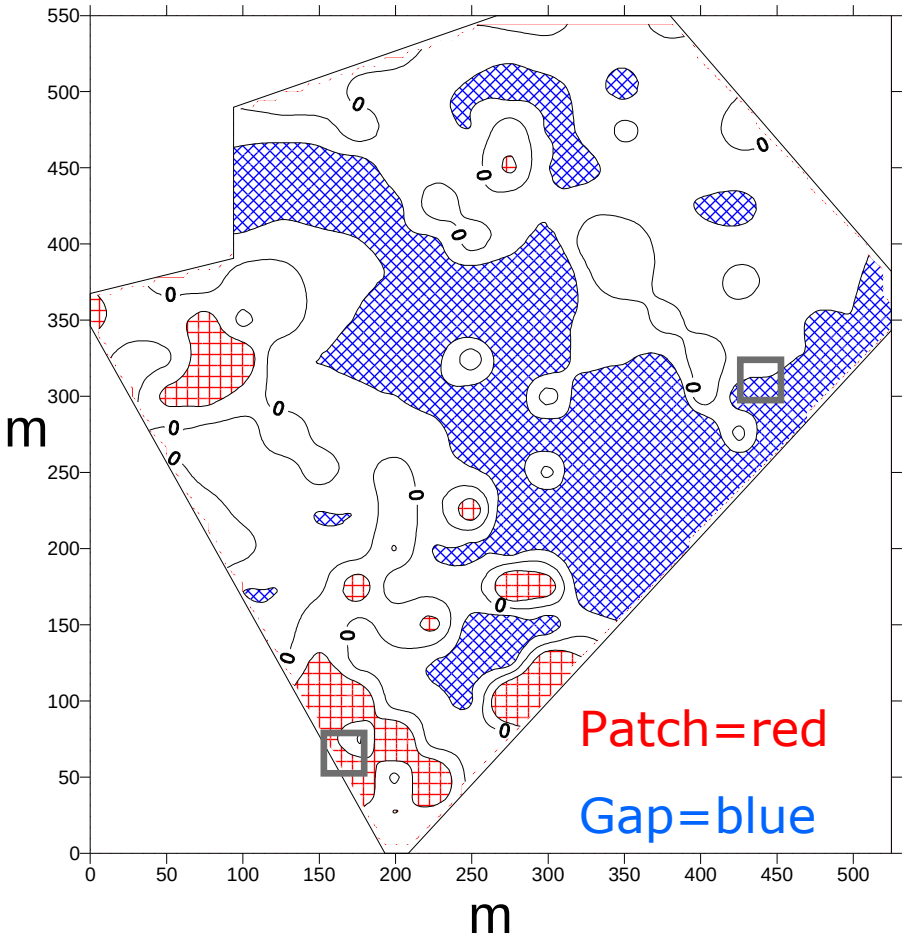
Location by GPS

B. bassiana: spatial statistics

V_j = -1.686; p = 0.0012

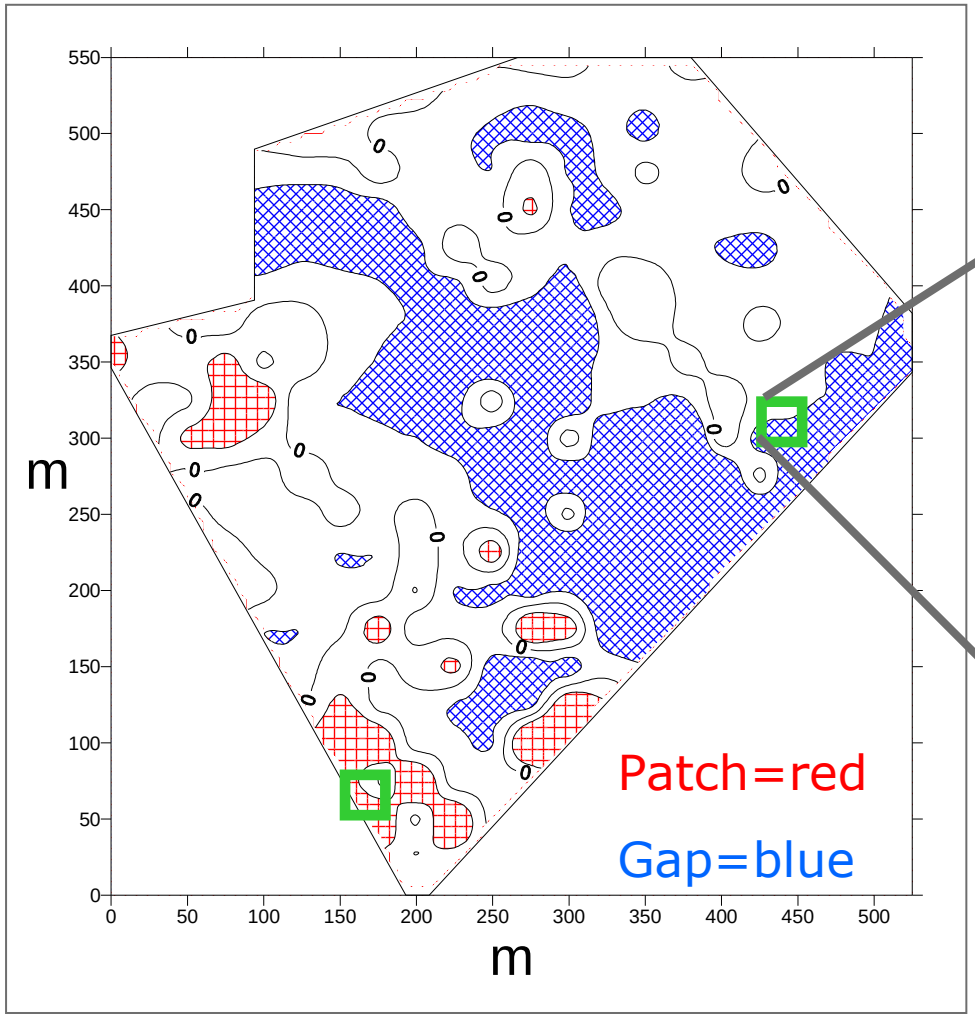
V_i = 1.772; p = 0.0003

Significant clustering

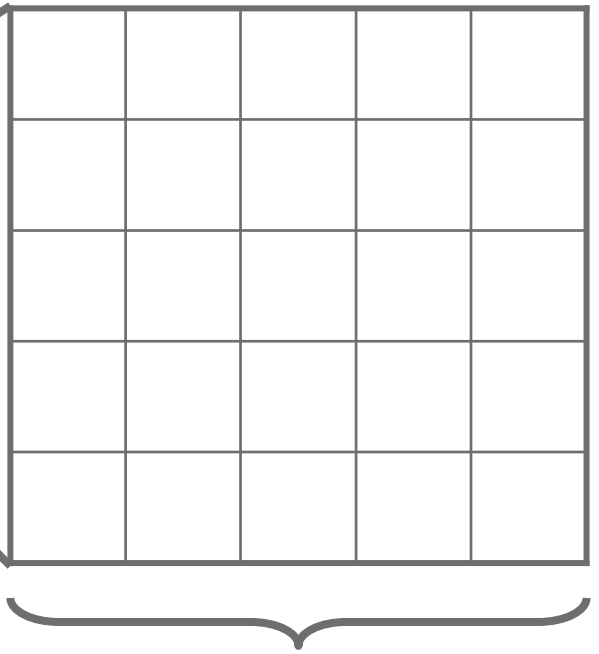


Meyling and Eilenberg (2006) *Agriculture, Ecosystem and Envrionment*, 113, 336-341

Have we found the distribution pattern ?



- quadrates between original sampling points



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

Percent positive samples from 'Patch' and 'Gap' quadrates

	'Patch'	'Gap'	Chi^2	P
25x25 (n=25)				
All fungi	84	36	12.00	0.0005
B. bassiana	68	16	13.88	0.0002

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

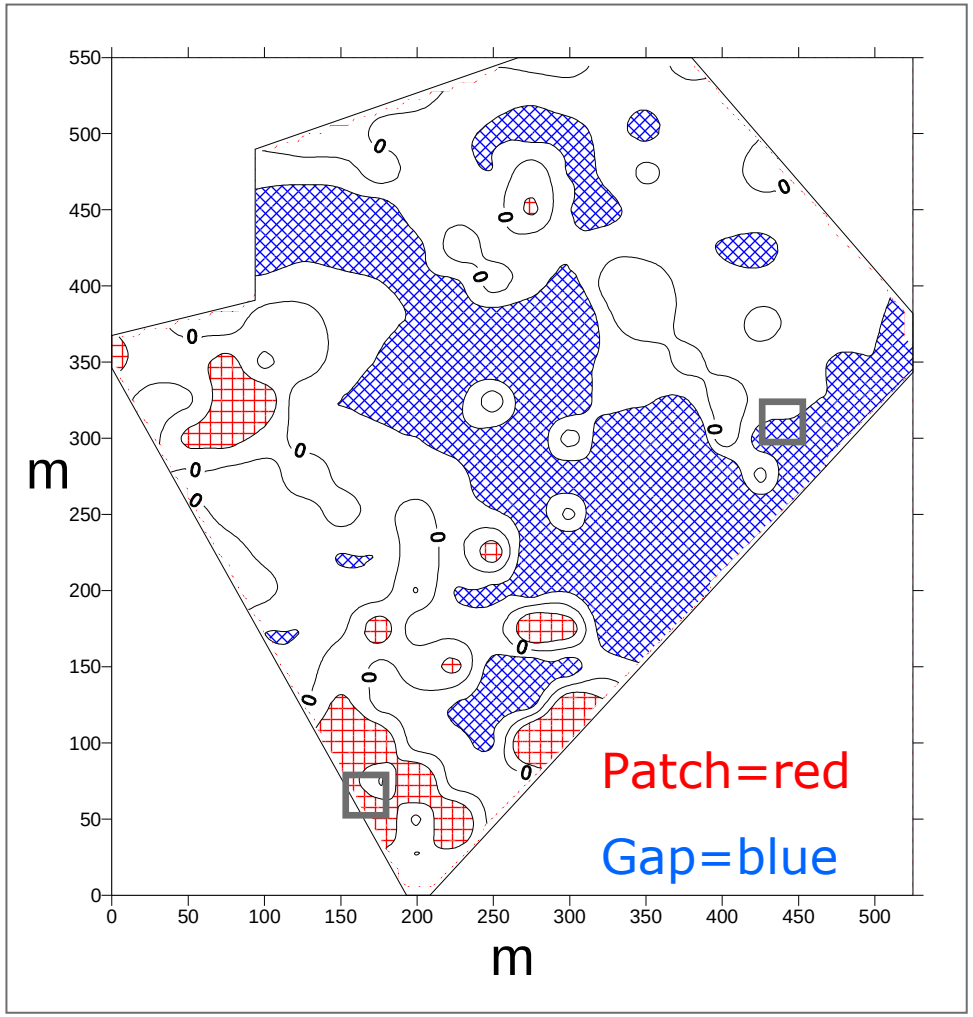
Reducing distance between sampling points confirmed results from the whole field assessment

Continuity of 'Patch' and 'Gap' quadrates 2003-2006

(n=25)	2003	2006	Chi²	P
All fungi				
'Patch'	84	96	2.00	0.1573
'Gap'	36	48	0.74	0.39
B. bassiana				
'Patch'	68	80	0.9356	0.3334
'Gap'	16	32	1.7544	0.1853

Based on MSc thesis 2007 by Vibeke Ærø Hansen

Horizontal distribution at Bakkegården



- *B. bassiana* patches and gaps:
  - identified
  - persistent in time
- Why patches ?
- Where to get representable sample from this site?

Fungal entomopathogens in soils: do they go above ground?

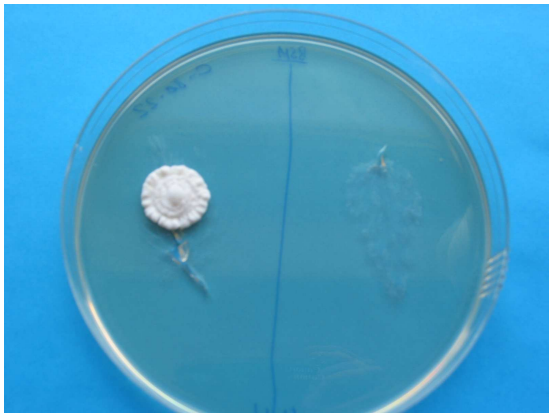
Same fungal species in soil and insects

- Are they really the same ?
- Do similar genotypes cycle below and above ground ?

Molecular identification

Co-occurrence in time and space

Bakkegården – *Beauveria* spp. below and above ground

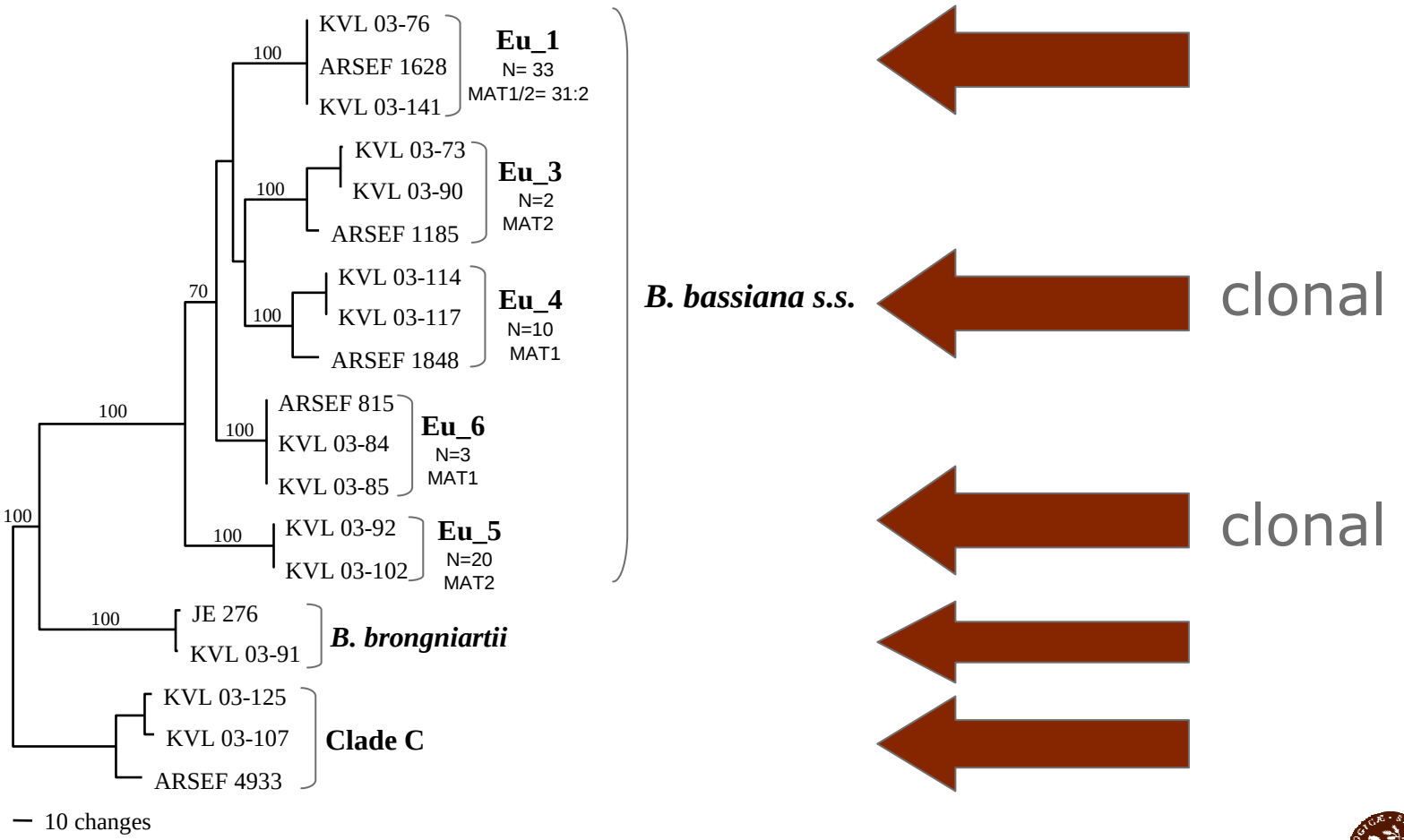


Beauveria bassiana morphospecies = cryptic species complex

- Single locality (hedgerow)
- Local insect community
- Host plants in hedgerow
- Soil of hedgerow

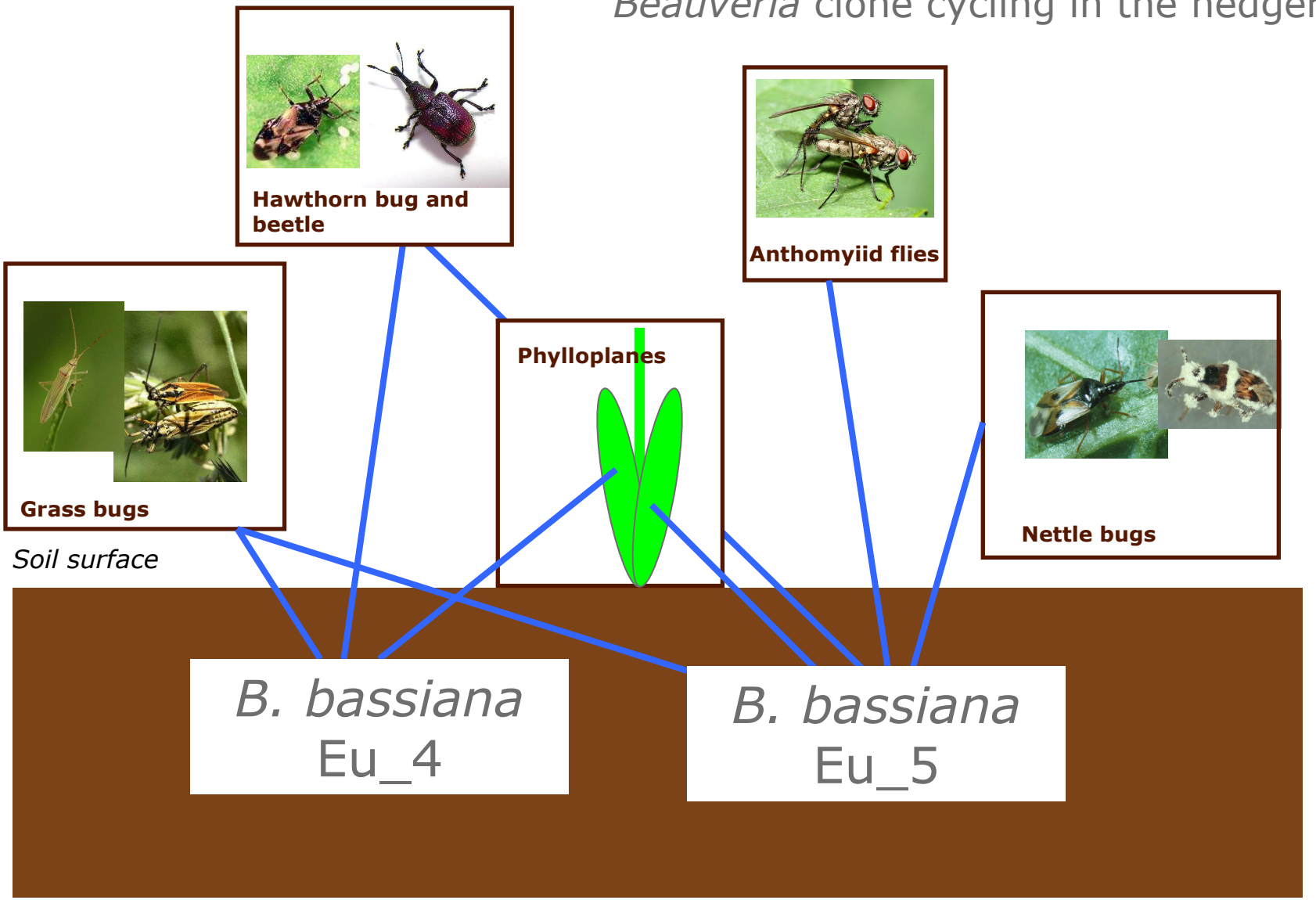
Meyling *et al.* (2009) *Molecular Ecology*, 18, 1282-1293

Molecular diversity of *Beauveria* community



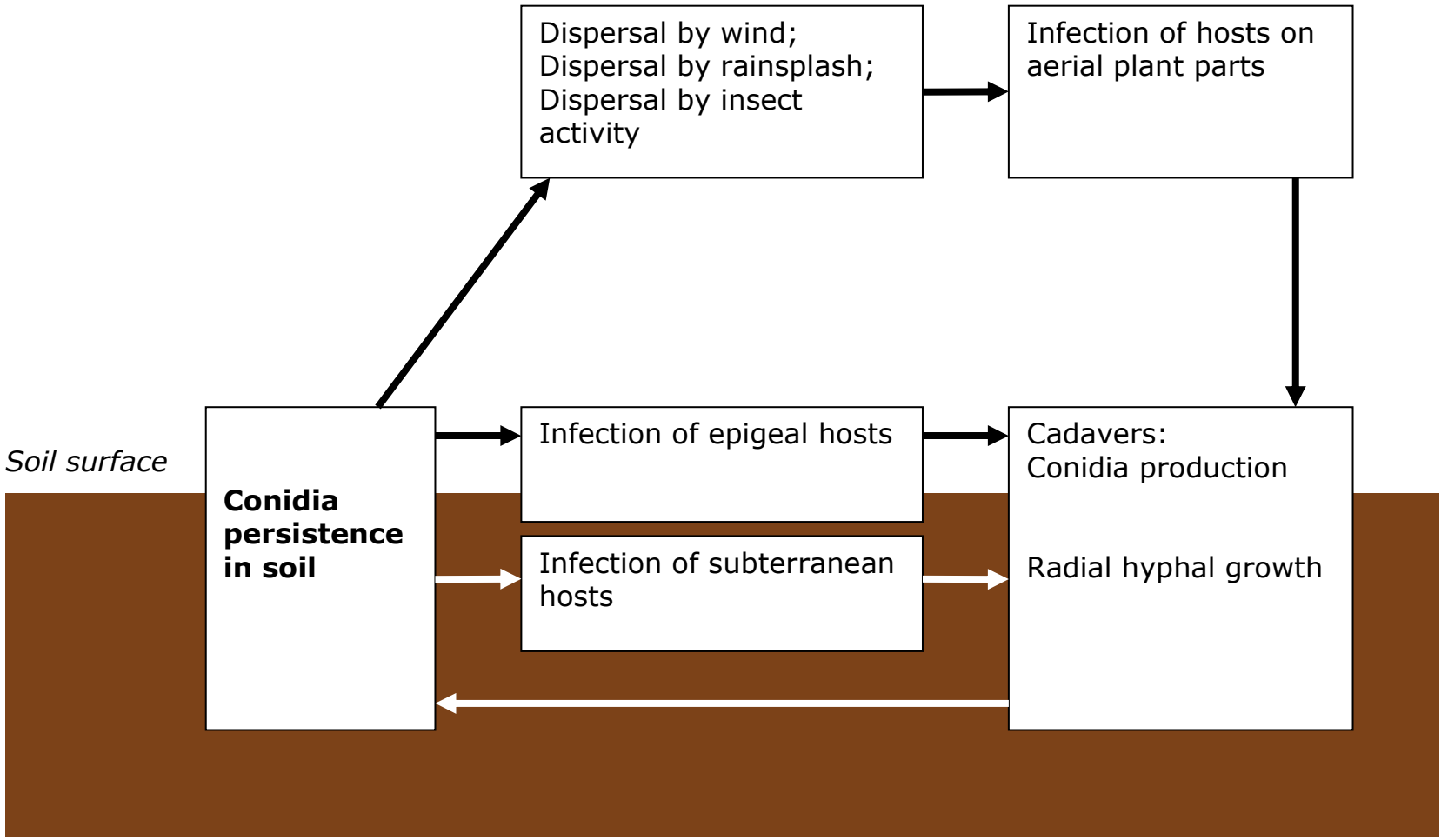
Meyling *et al.* (2009) *Molecular Ecology*, 18, 1282-1293

Beauveria clone cycling in the hedgerow



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

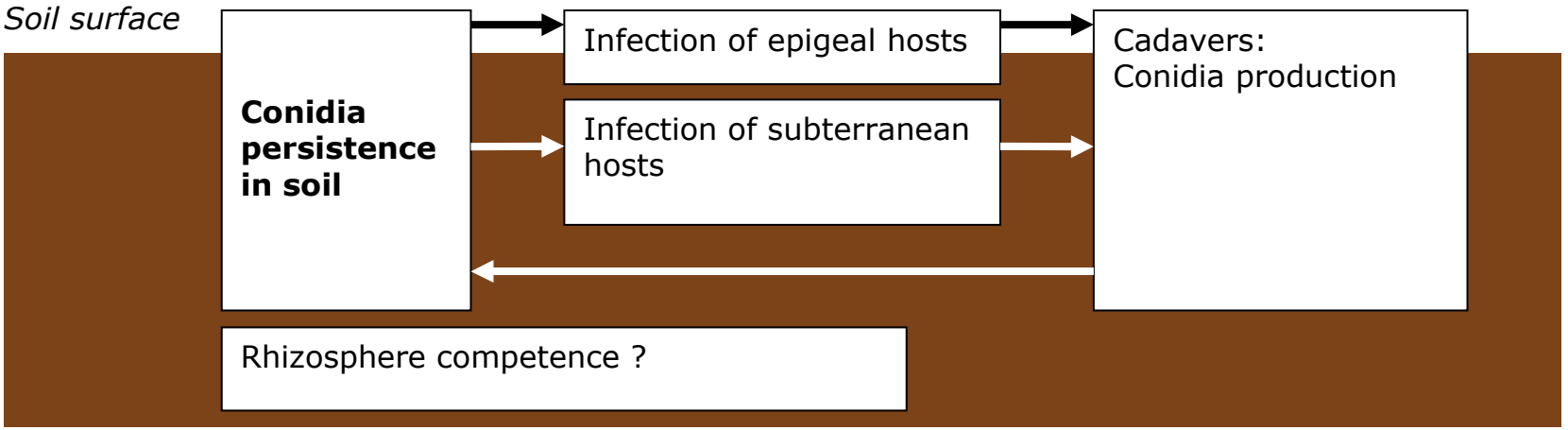
Beauveria bassiana dynamics



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

Metarhizium anisopliae dynamics

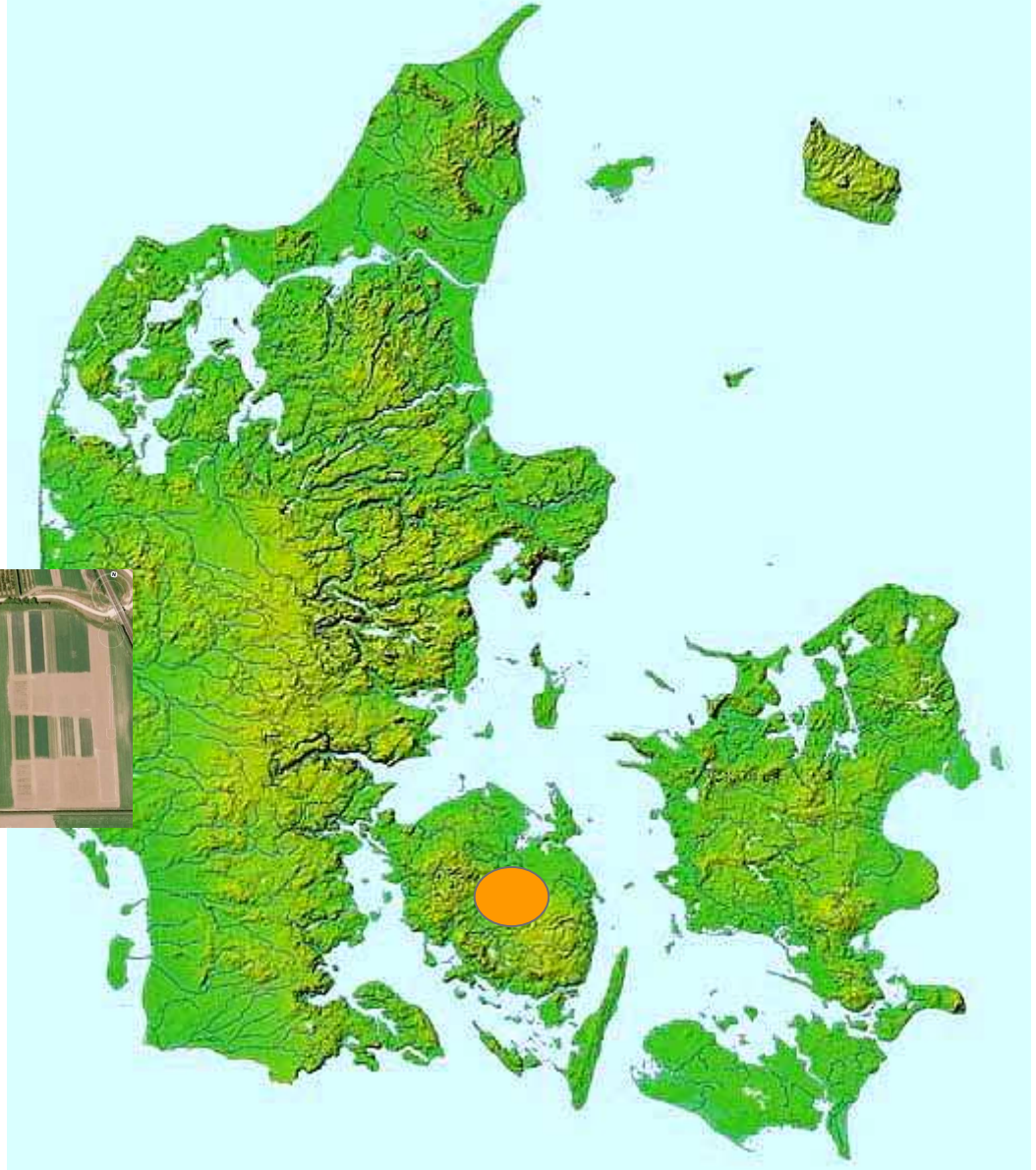
- no above ground cycling?



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

Fungal entomopathogen communities above and below ground

Årslev



Soil sampling and collection of arthropod fungus-cadavers

Below ground = above ground ?

High arctic environments - Greenland

Disko:

I. farinosa

B. bassiana

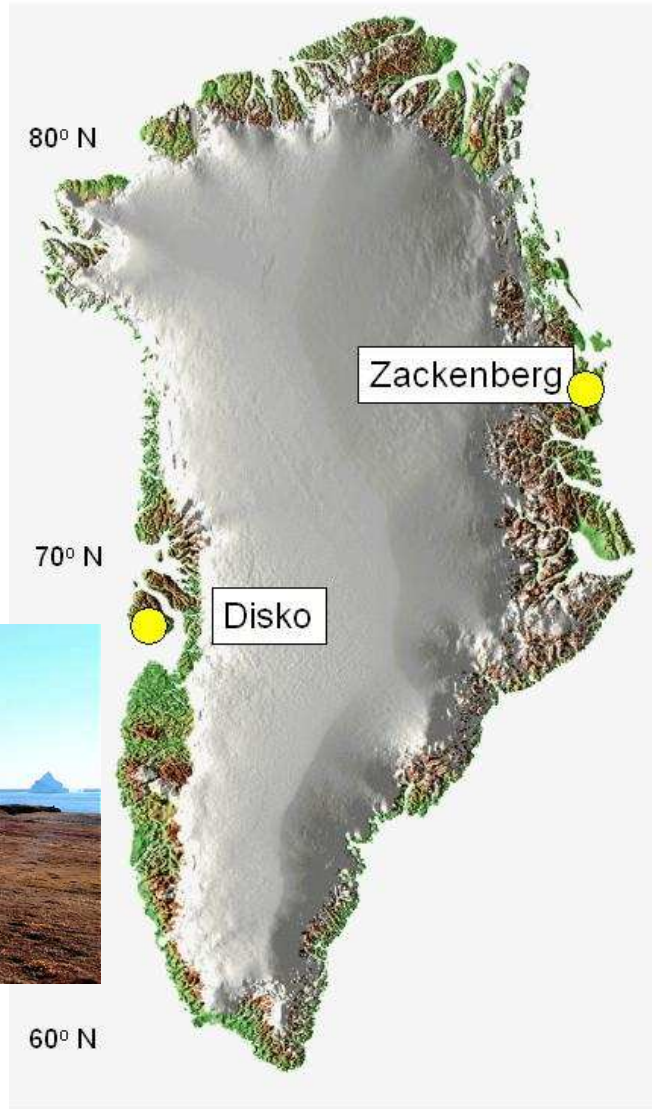
T. inflatum

Ritenbenk:

I. fumosorosea

I. farinosa

B. bassiana



Zackenberg:

I. fumosorosea

I. farinosa

Danmarkshavn:

I. fumosorosea

I. farinosa

B. bassiana

Unpublished data

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