Conservation biological control of codling moth, *Cydia pomonella*

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Challenges for Danish organic apple production

The production is small and unstable due to yield and quality loss from key pest and diseases

Lack of suitable cultivars for producers

Lack of suitable weed control strategies

Lack of suitable storage strategies

In market competition with imported organic apples

2011-2014 Fruitgrowth-
Novel organic solutions securing future growth

WP3.1 *Ecological infrastructures*

Partners:
University of Aarhus
University of Copenhagen
University of Southern Denmark

Danish fruit growers organisation
Adv.service: Gefion, HortiAdvice Scandinavia
Company: ENVODAN

Farms: Ventegodtgaard, Strandegaard

Apple production in Denmark

62% of the country is cultivated

Apple is the major fruit with 1,700 ha

Stats-kontrolleret økologisk

18% is organic (2011). Average yields are 14 tons per ha.

Often only about 20% of apples from organic orchards meet the first class standards. Rejected apples are sold as apple juice, presently, however, at a fair price.

Main pests: apple sawfly (*Hoplocampa testudinea*), codling moth (*Cydia pomonella*), rosy apple aphid

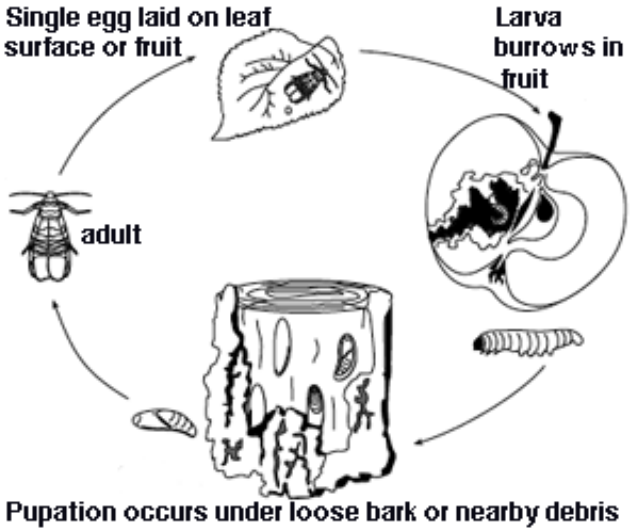
Diseases: apple scab (*Venturia inaequalis*),apple canker (*Nectria galligena)*.

Permitted to use is

Pheromone disruption (from 2011), CM virus (from '11), *B. thuringiensis*, sometimes special dispensation for natural pyrethrum,

Conventional apple orchards: avg sprays is 20, 1-3 are insecticides.

Codling moth life cycle



Sources: UC Davis, HYPPZ

Codling moth damage

Damage depend on

- Biotic and abiotic factors such as
  - Temperature
  - Cultivar
  - Natural enemies
- Crop protection methods

Where 1 generation 2-35% damage reported

Where 2-4 generations damage can be 65% or more

www.havenyt.dk

www.plante-doktor.dk

Key questions

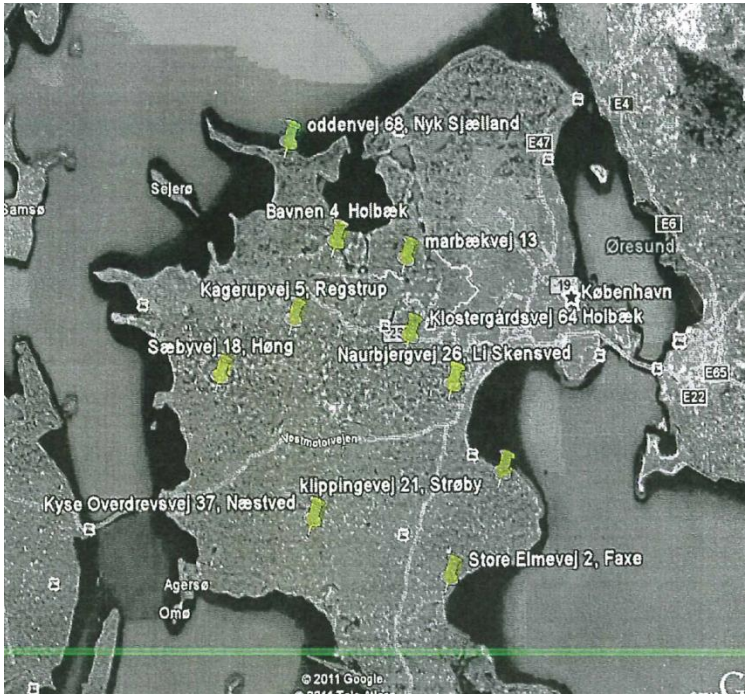
- Can increased plant biodiversity in orchards improve regulation of the codling moth
- Can differences be found between orchards with flower strips and without (Bostanian 2004)
    - Infestation with codling moth
    - Parasitism and other mortality
- Can a distance effect of flower strip be found between trees next to flower strip (2 m) and 3 rows away from the strip (10 m)
    - Infestation with codling moth
    - Parasitism and other mortality
    - Egg predation
    - Functional biodiversity

Orchards

10 organic orchards, 5 with grass, 5 with flower strips.

Orchards established 2000-2003, one in 2008.

Flower strips replaced an inner tree row (one flower strip after 5 rows of apples or were in the side of the orchard (2 places) and were established by the time of planting the orchard.



Zealand, Denmark

Seedmix used to rejuvenate strips spring 2011

Lotus corniculatus
Achillea millefolium L.
Sinapis alba
Borago officinalis
Centaurea cyanus
Centaurea jacea
Daucus carota
Leucanthemum vulgare
Matricaria reticulata
Medicago lupulina
Fagopyrum esculentum
Trifolium incarnatum
Carum carvi
Anthriscus cerefolium
Cichorium intybus
Onobrychis viciifolia
Medicago sativa

Flower strips

Experiments

10 organic orchards sampled in 2011 and 2012 for overwintering codling moth.

In 2012 5 orchards (with flower strips) sampled (beating and sweep net) for predators as a function of distance to flower strip in May, June, July. In 2013 beating sampling was repeated

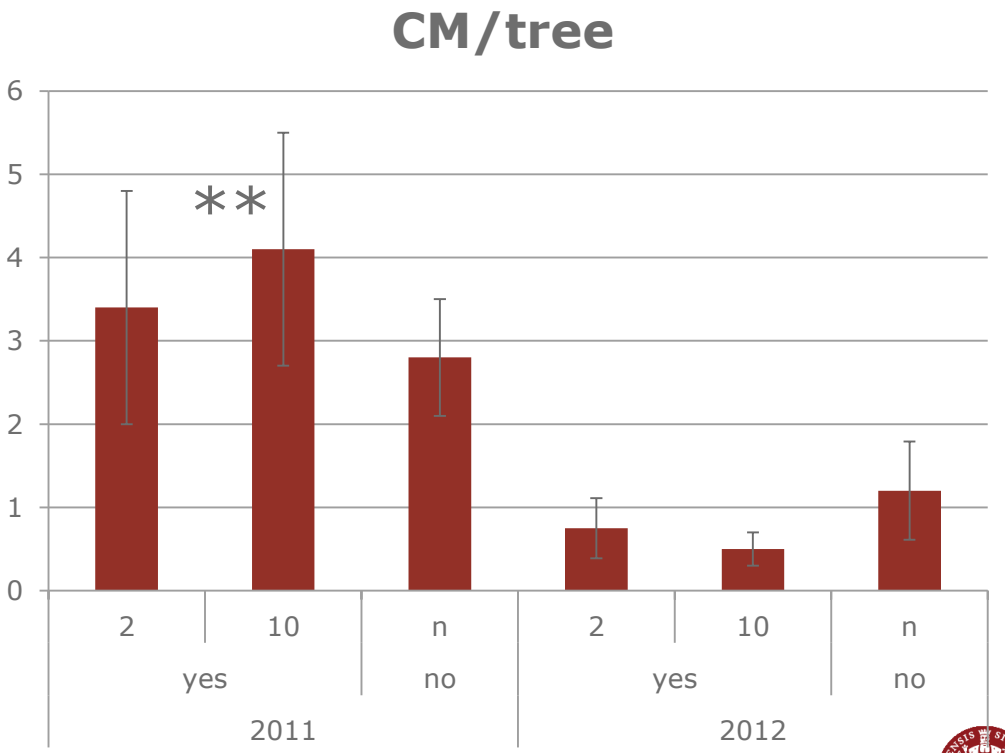
Sentinel eggs (*Sitotroga kuhniella*) were used to assess predation activity as function of distance to flower strip in 2012, May, June, July. In 2013 codling moth eggs were used as sentinel prey -also in May, June and July/August.

Codling moth damage was assessed in summer 2011, 2012 and 2013

Codling moth infestation

CM infestation level (Corrugated cardboard band)
2011: 1179 CM from 350 trees.
2012: 369 CM from 405 trees.

Year x orchard type is significant
More decrease in numbers of CM in orchards with flower strips



Parasitism

20-30% parasitism of overwintering larvae.

Significant orchard type x year interaction

Higher parasitism in orchards wo flower strips in 2011 and
Higher in orchards with flowerstrips in 2012
(parasitism correlated with CM densities)

No effect of distance to flower strip

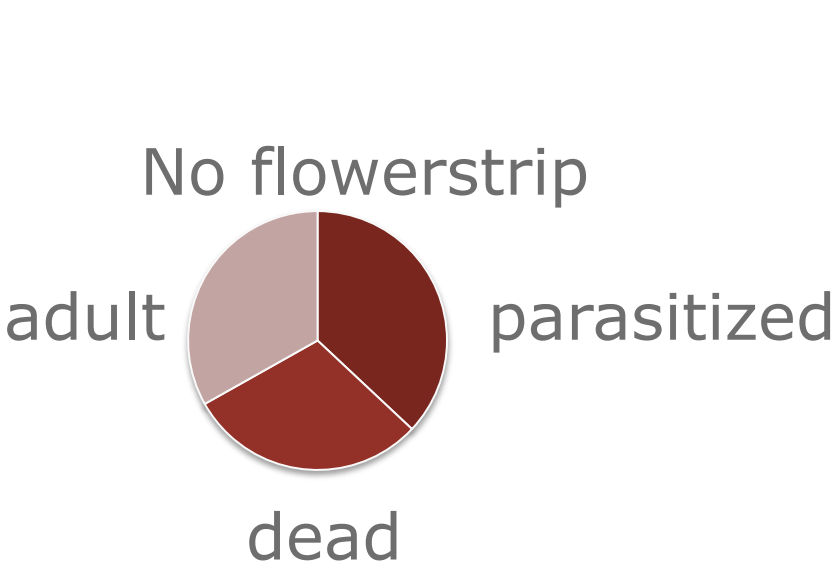
Dominant parasitoid ***Trichomma enecator*** > 75%
Also: *Pristomerus vulneratur*, *Ascogaster quadridentata* and few Tachinids

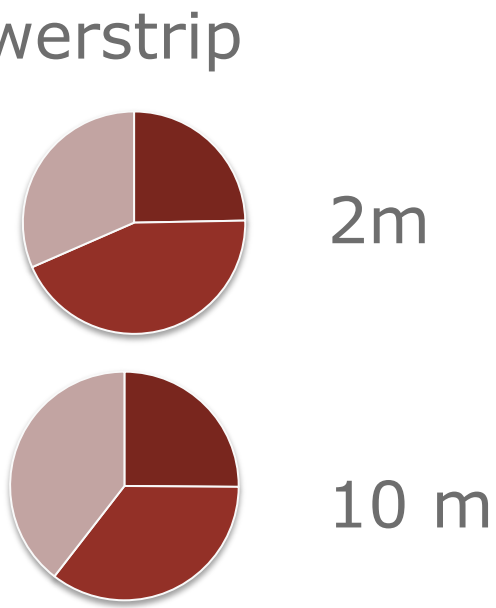
Trichomma was more dominant in orchards without flower strips (89%) than in orchards without flower strips (71%) in 2011

Unknown mortality

Unknown mortality near 30%

10% higher mortality near flower strip. Significant in 2011





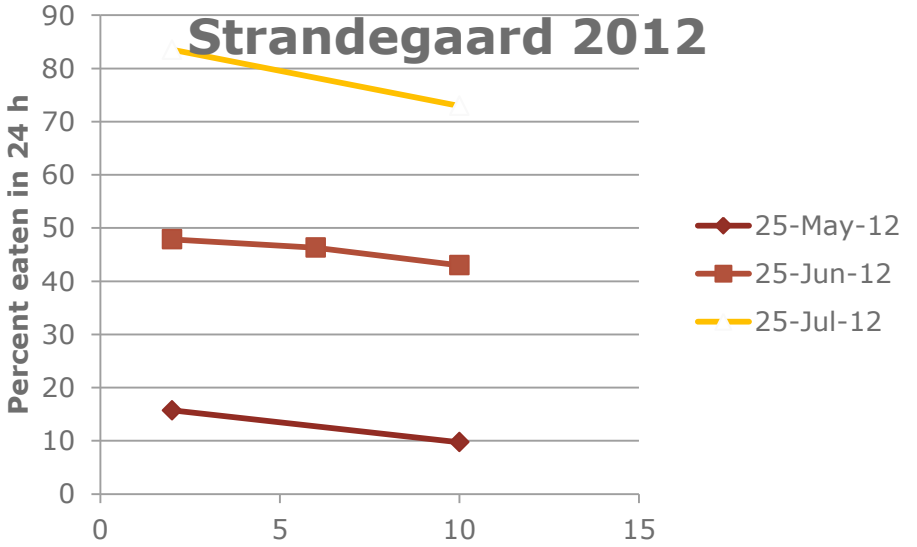
Egg predation and parasitism on sentinel prey

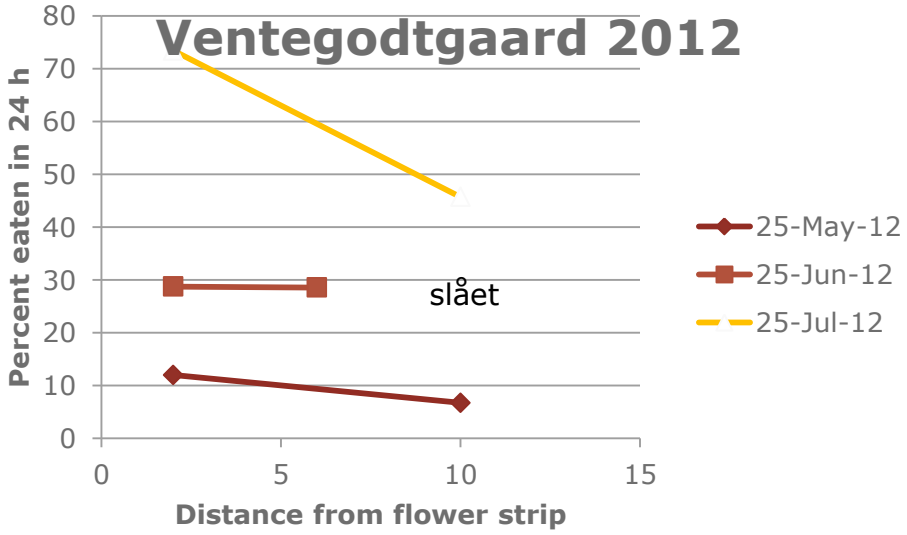
2012: Egg cards with sentinel prey *Sitotroga ceralella*
-5 orchards w. flower strips assessed May –June -July

2013: Sentinel prey of CM eggs in 5 orchards with flower strips.
May –June –July
Compared with orchards without strips in June

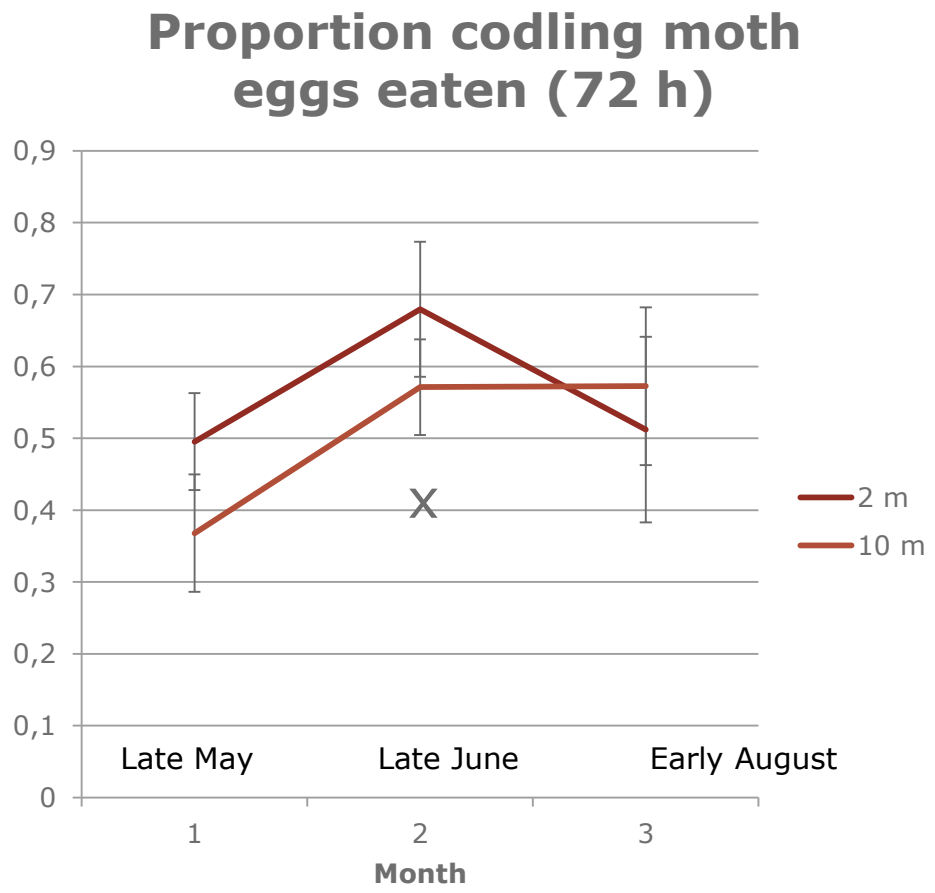
No egg parasitism found in either year

Egg predation as a function of distance to floral strip





2013 sentinel prey of codling moth eggs



Predation in late June in orchards wo flower strips was 43% eggs eaten in 72 h

Fruit damaged by codling moth

2011:
14% damage in orchards without flowerstrip early July,
26% in orchards with strips –(same 2m from strip and 10m from strip).
Difference NS because of variability

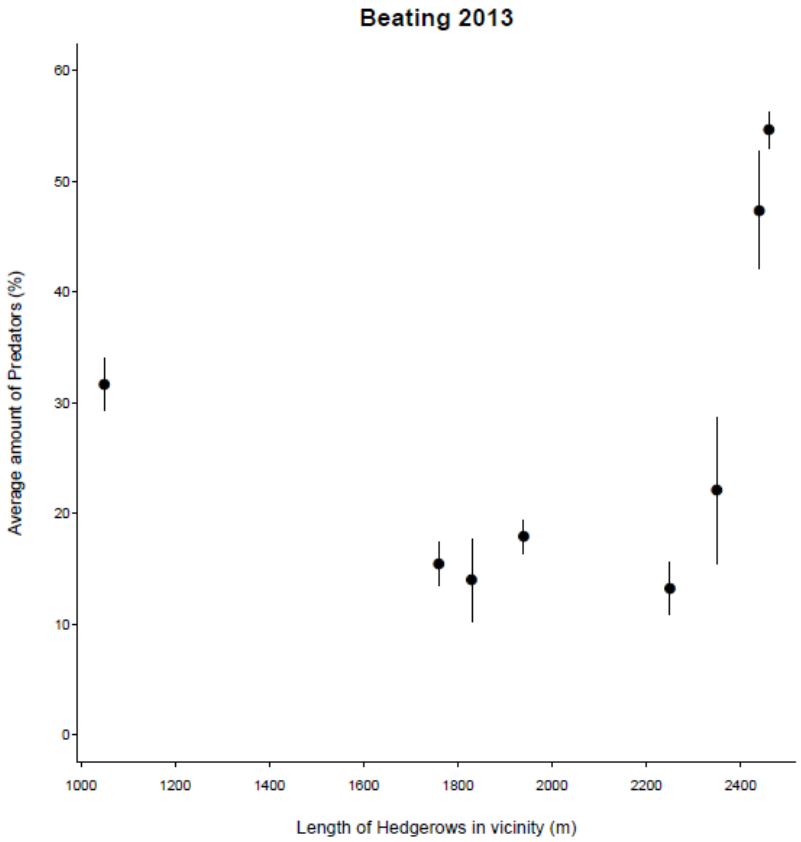
2012: few apples CM damaged. Cold and wet summer.

2013: June –near strip 2% damaged, away from strip 3.2% damaged
August –near strip 0.1%, away from strip 0.2%
Difference significant.

Functional biodiversity –samples from orchards with flower strips 2012 and 2013

Results to follow

Landscape factors



Conclusions

- Effect of distance from flower strip (2m vs 10 m) on
  - number of overwintering codling moth –fewer overwintering near flower strip
  - Proportion larvae dead in rearing -higher mortlity near flower strip
  - Egg predation increasing over season and higher egg predation near flower strips
  - Trend of fruit damage being reduced near flower strip, significant in 2013
- Effect of orchard less clear
  - More infestation (NS) where flower strips in 2011, reversed in 2012
  - No effect of parasitism of overwintering larvae
  - Trichomma less dominant in orchards with flower strips
  - Higher egg predation in orchards with flower strips (assessed June)

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Next step

PROTECFRUIT -
Protected production of organic apples and pears

WP: Effect of functional biodiversity on the rosy apple aphid