

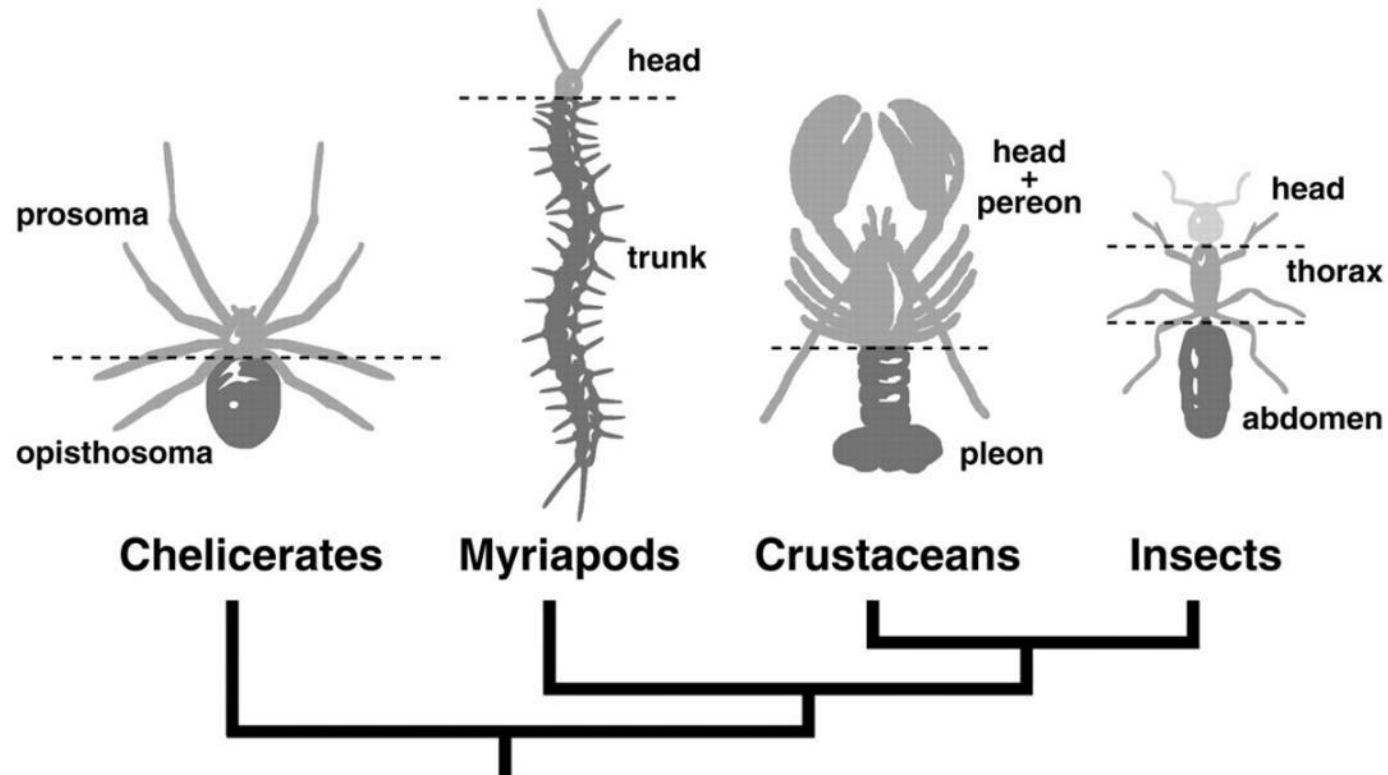
Varroa føde og føde søgning samt varroas direkte effekter på bier

Annette Bruun Jensen

Institut for Plante- og Miljøvidenskab
Det Natur- og Biovidenskabelige Fakultet

KØBENHAVNS UNIVERSITET





Fire underækker:

Chelicerata (mider og spindlere)

Klosakdyr, på 3. segment sidder klosaksene (*chelicerae*)

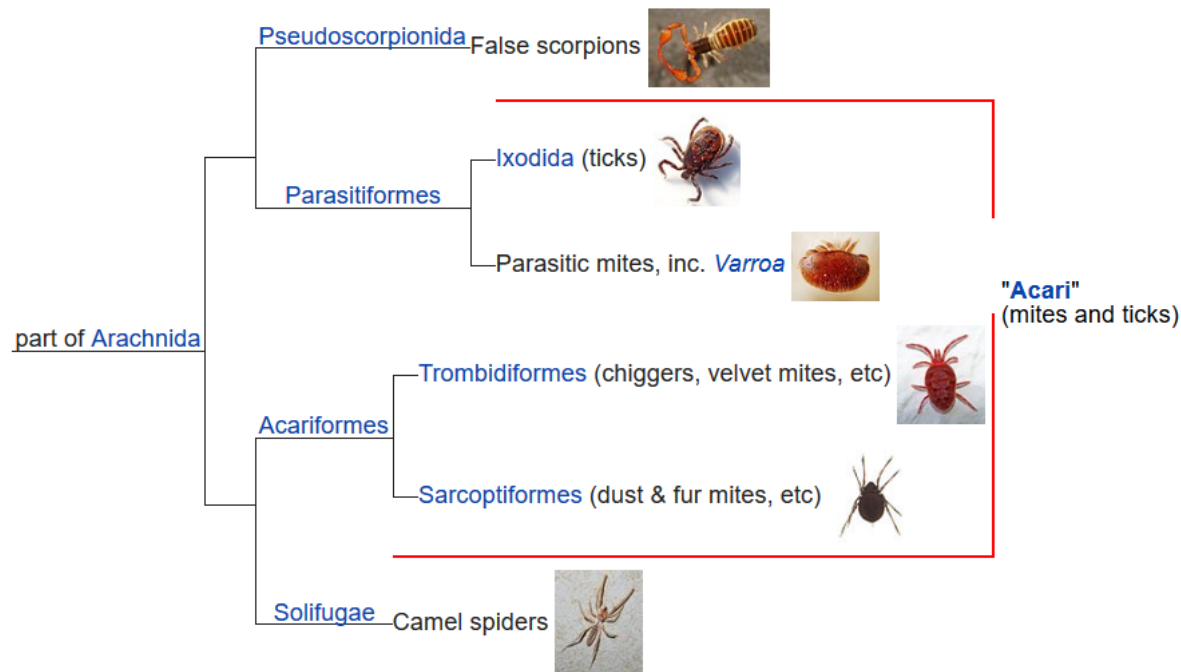
Myriapoda (tusindben og skolopendre)

Crustacea (krebsdyr)

Hexapoda (insekter)

Mider – en af dem Varroa

- Mider er små arthropoder
- >50.000 beskrevne arter (men nok over 1.000.000)
- Mange forskellig livsformer i alle habitater, nedbrydere og parasitter
- Parasitter ernære sig af levende organismer



Hvad lever varroa miderne af?

Varroa har bidende og sugende munddele

De får deres kost fra larve, pupper og voksne honningbier

Kosten er flydende



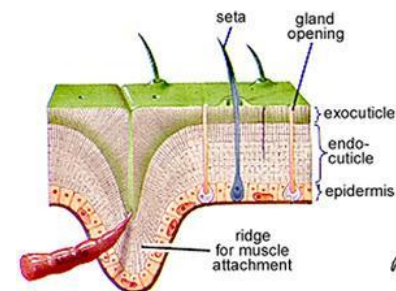
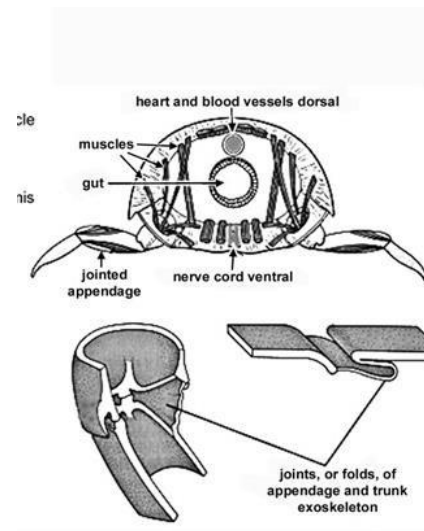
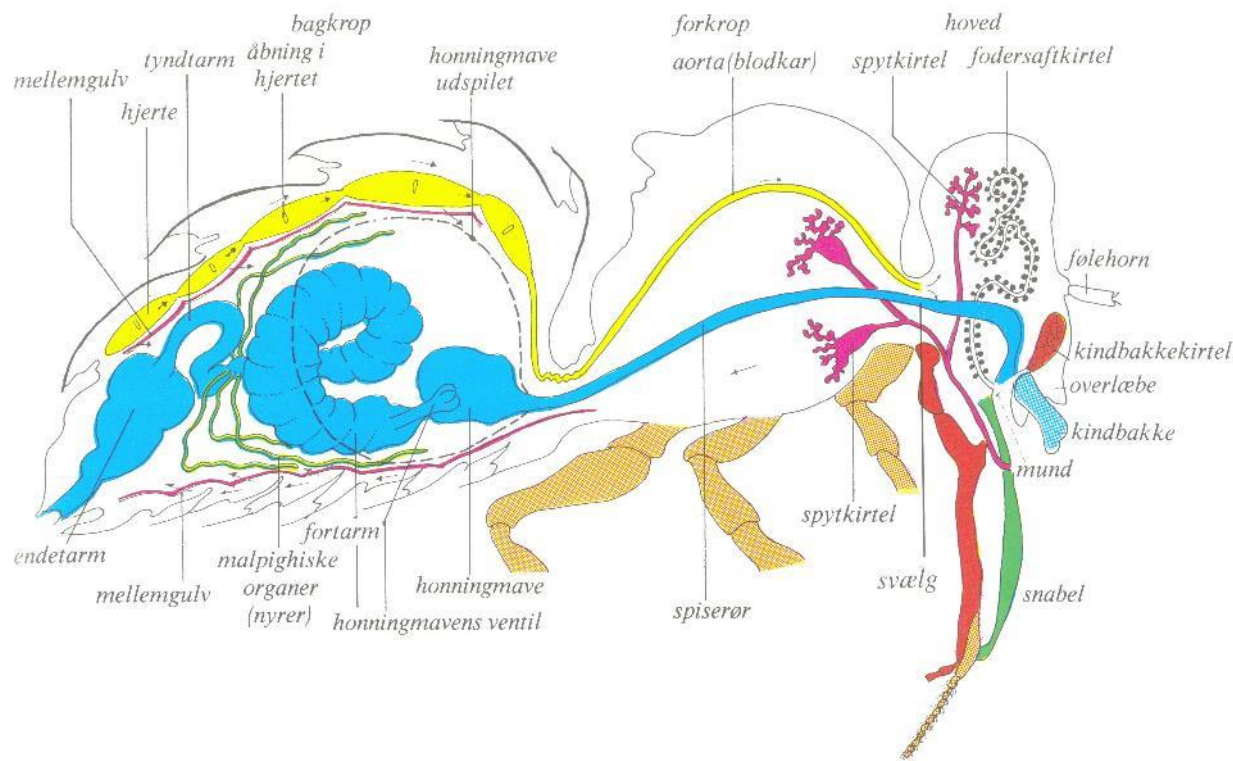
Flåter og varroa hvad har de til fælles?

<https://www.youtube.com/watch?v=aJHjUMZVRKA>

Begge er mider

Begge skærer, spytter enzymer og suger mad

Tværsnit af en bi – Ydre skelet og åbent blodsystem



Varroahunnen laver et åbent sår i det ydre skelet

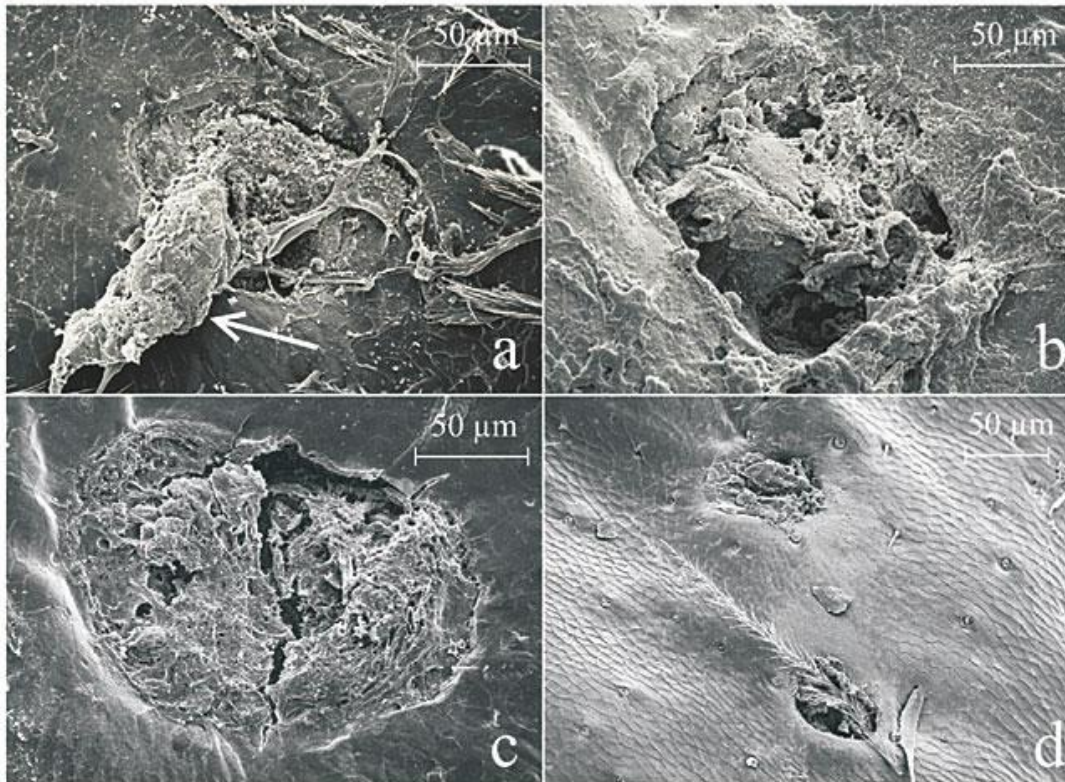
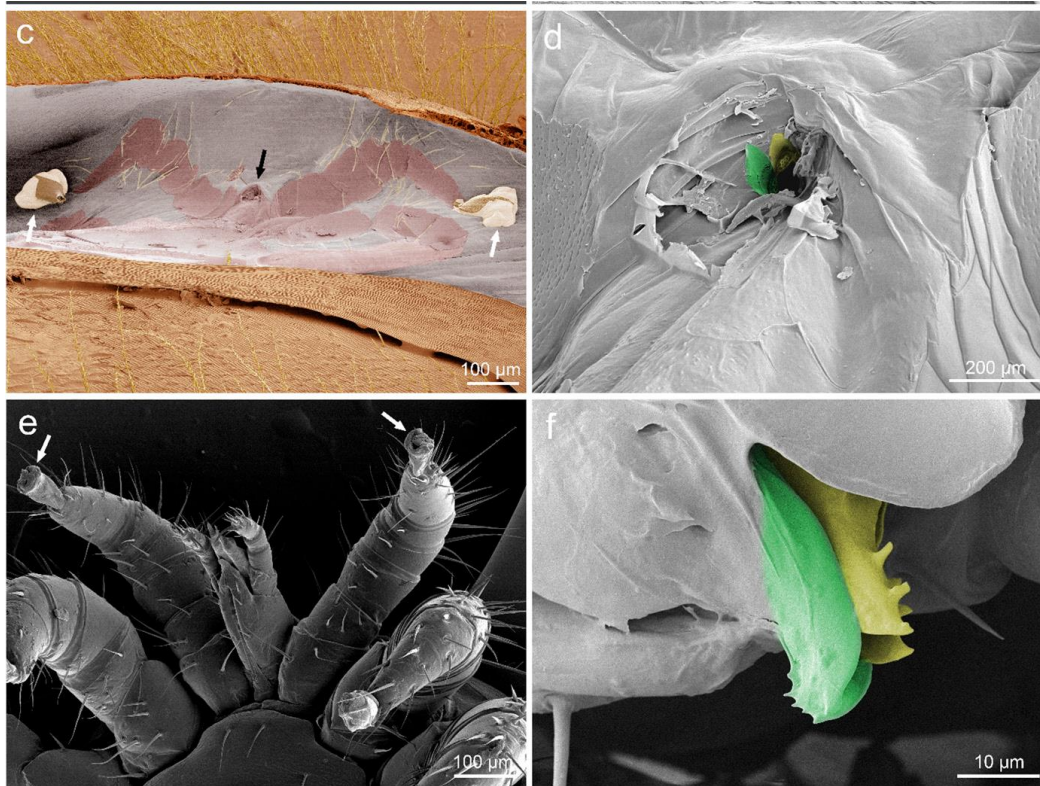
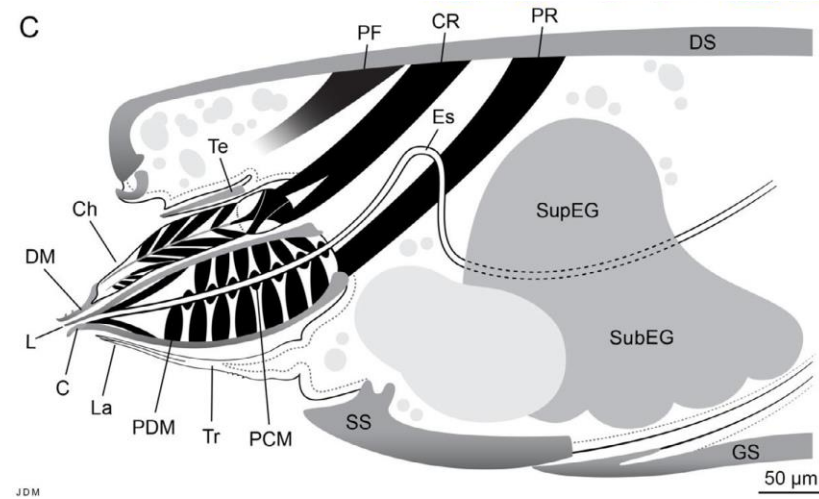


Figure 2. Scanning electron microscope photos of *Varroa*-made wounds in the integument of pupal honey bees. a = wound on drone pupa 21-22 days old, infested with three female mites. Hemolymph is leaking out of the perforation (arrow). b = wound on drone pupa 21-22 days old, infested with five female mites. Wound with deep holes around the margin. c = wound on worker pupa 20-21 days old, infested with four female mites. The large wound is only partly healed. d = wounds on drone pupa 21-22 days old, infested with two female mites, with two nearby perforations on the second abdominal sternite. Notice the developing hairs on the cuticular surface.

Movable digits – varroas skærende munddele

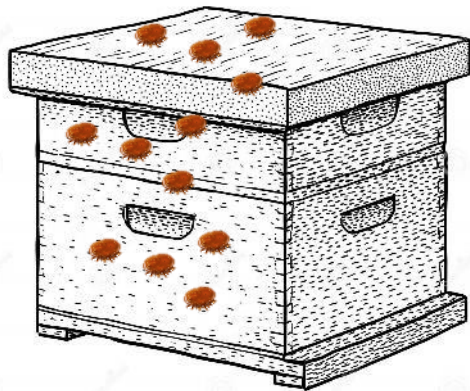


Ramsey et al 2019



Li et al 2019

Hunmidernes fødehuller



Lukket droneyngel i foråret



Lukket droneyngel i foråret

Droneyngel i forskellige aldre

16 dage

18 dage

20 dage



a

b

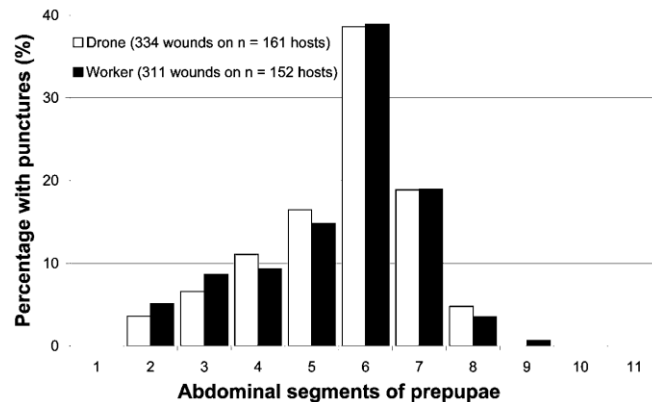
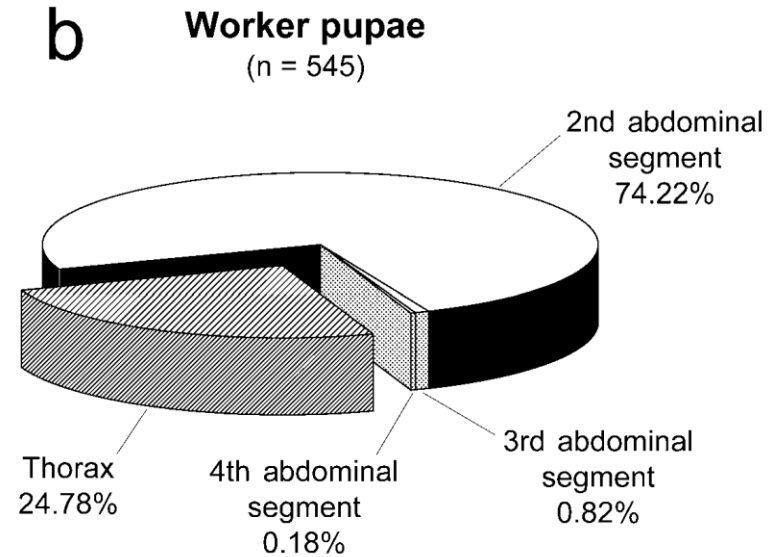
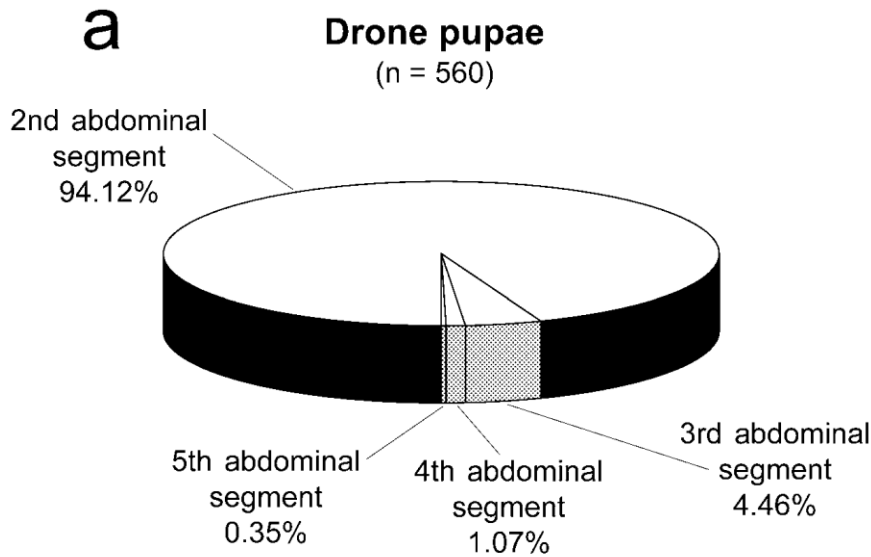
c

2. segment

4. segment

2. segment

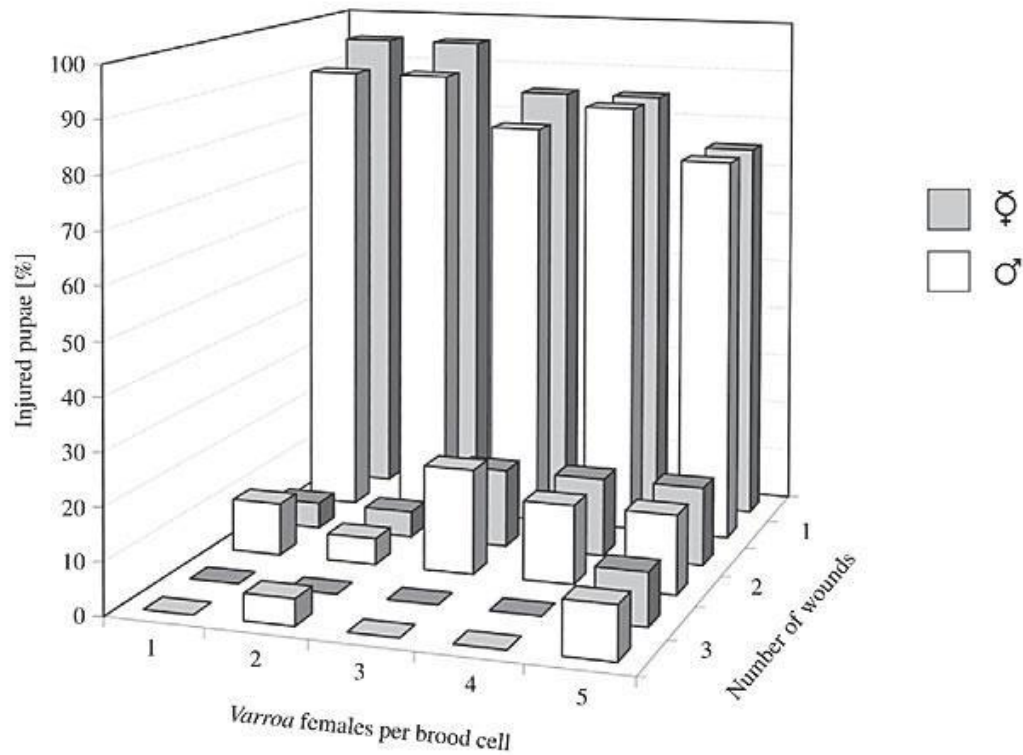
Fødehul-præference



Varroa i yngelcellerne



Fælles fødehul



Størrelsen af fødehuller

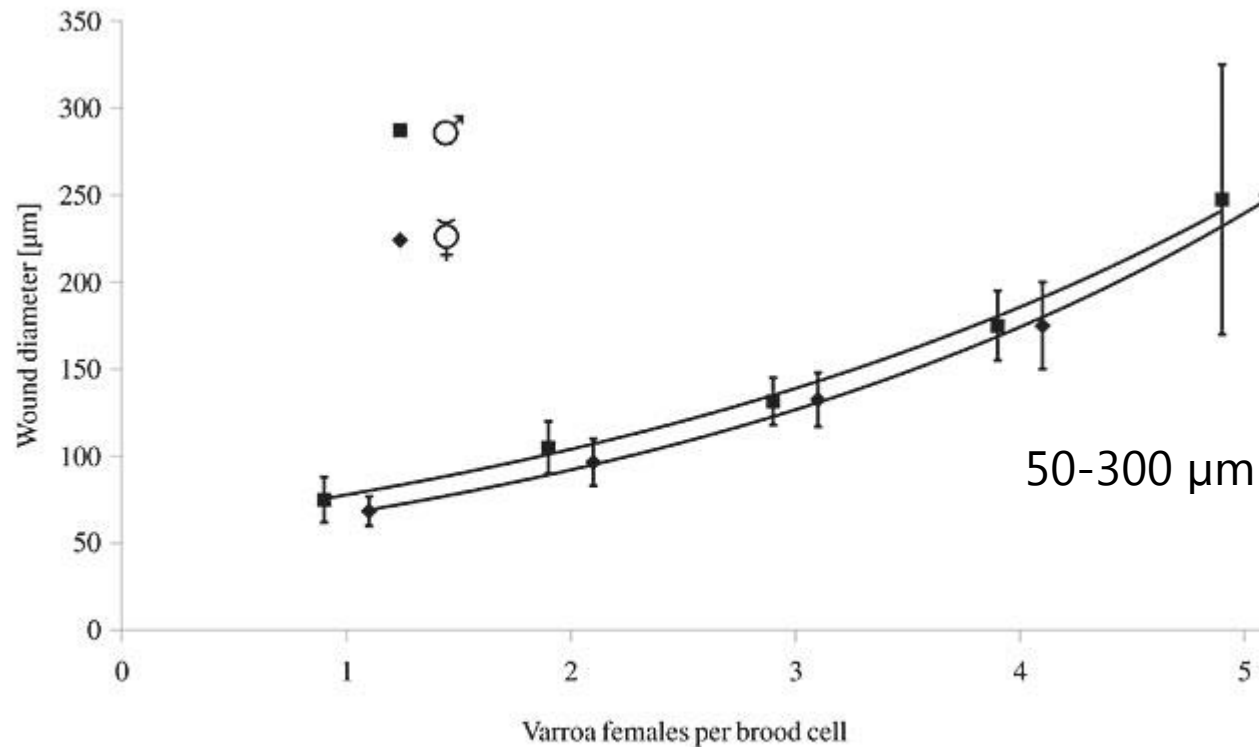
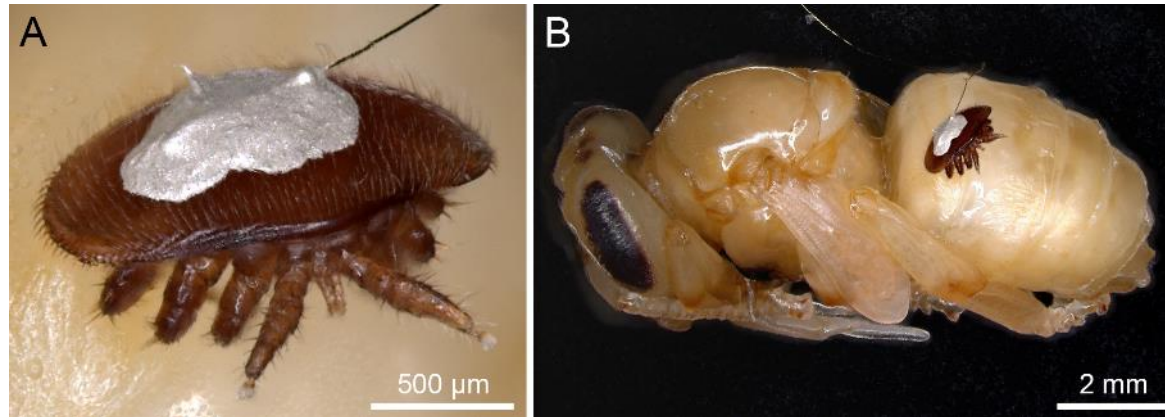


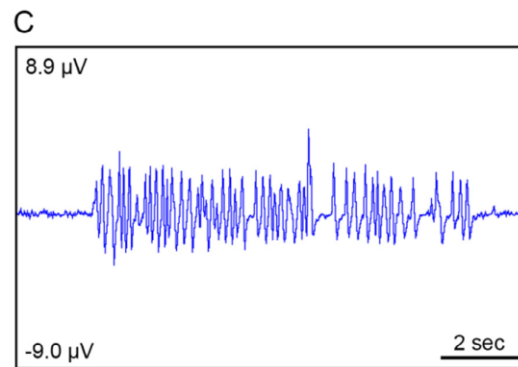
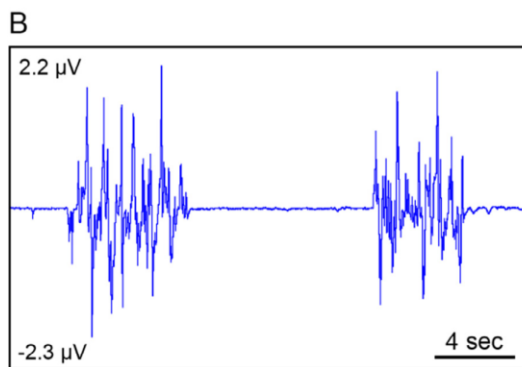
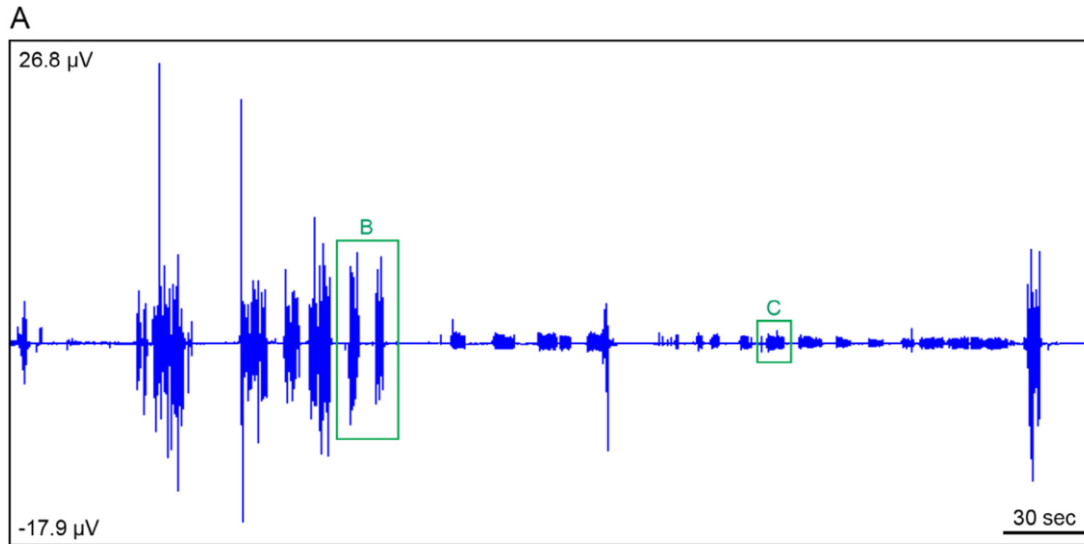
Figure 3. Size of *Varroa*-made abdominal wounds in drone and worker pupae of the honey bee in relation to the level of brood cell infestation. Bars indicate the range of the maximum diameter of the wounds about three days before adult bee eclosion. ♂ = drone; ♀ = worker.

Fødesøgning og fødeoptag – fancy udstyr



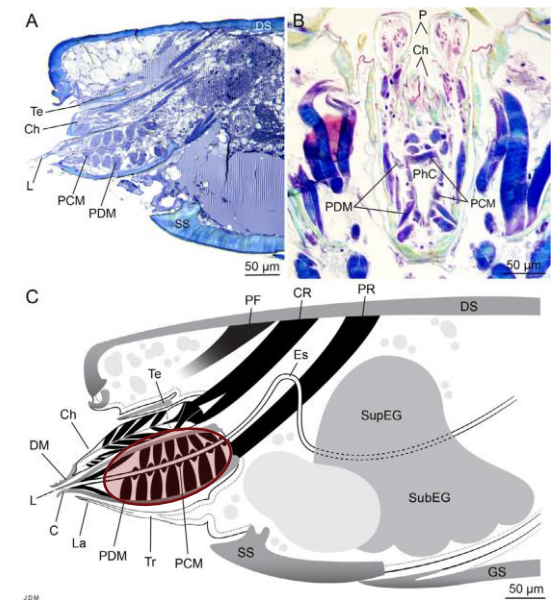
- (A) Female *Varroa* mite attached to gold wire with condensed silver paint and tethered to EPG apparatus..
(B) Placement of *Varroa* mite on integument of honey bee pupa.

Fødesøgning og fødeoptag – elektriske optagelser

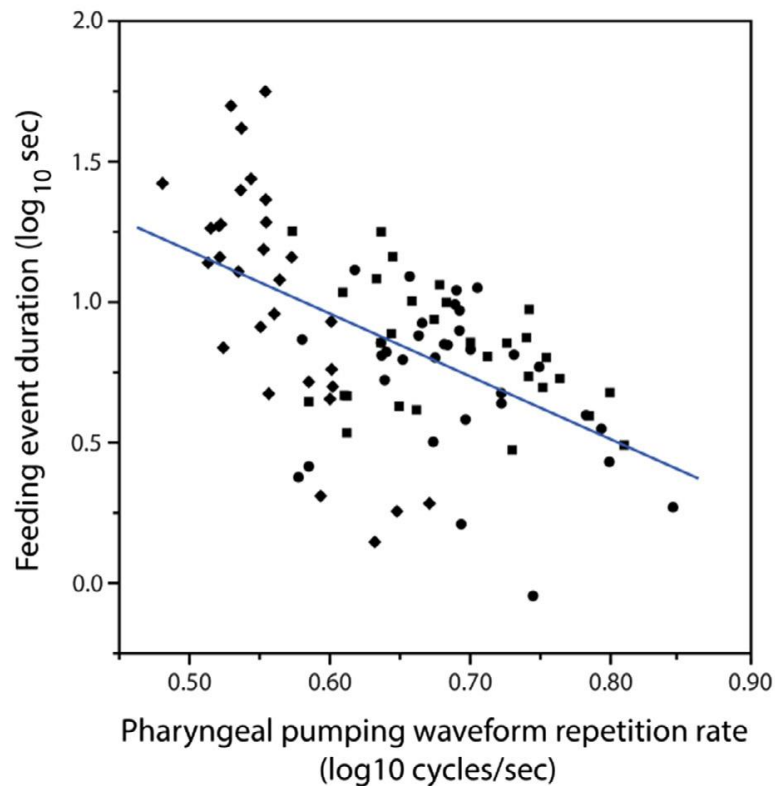
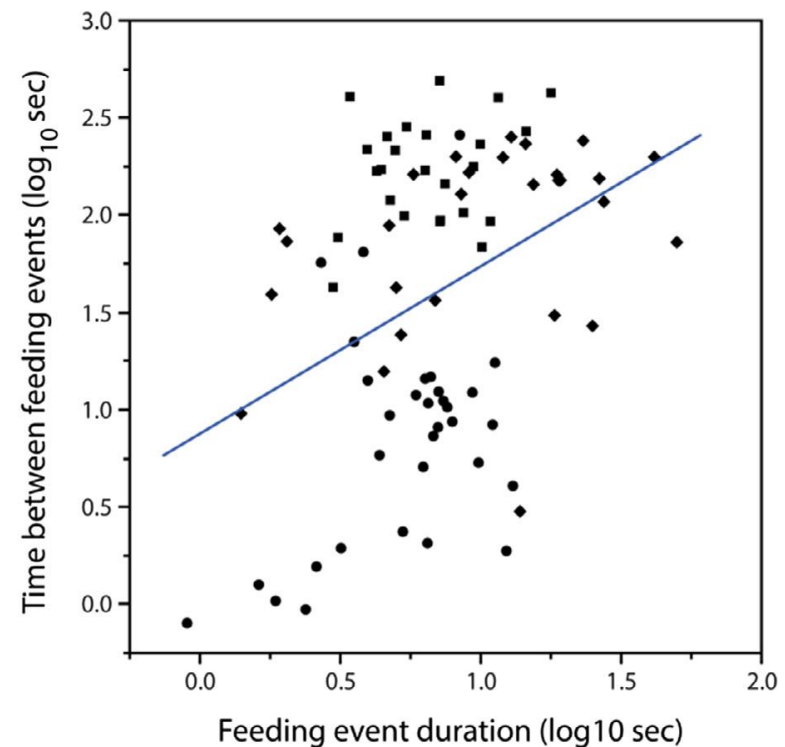


Varroamiden går rundt

Musklerne i svælget pumper



Varroa midens spisetid

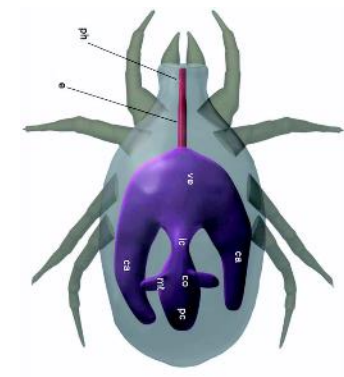
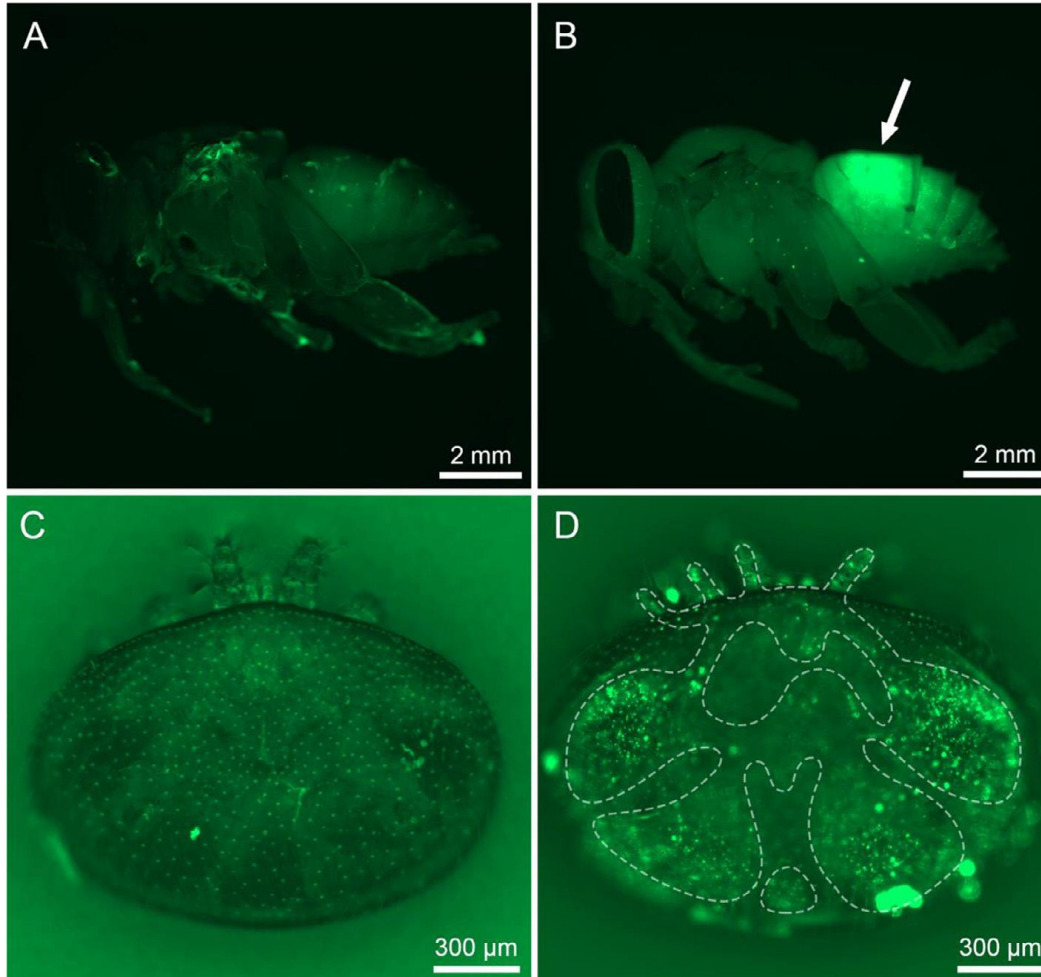
A**B**

A. Jo hurtigere svælget pumper jo kortere tid spiser miden

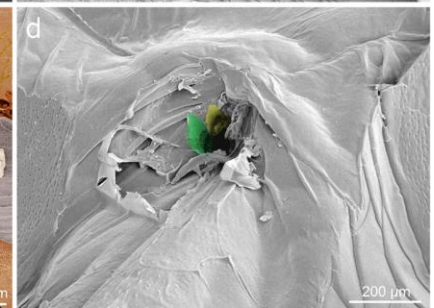
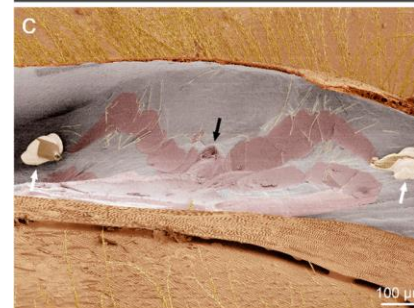
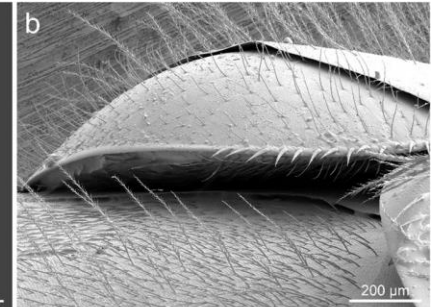
B. Jo længere tid der er mellem måltiderne jo længere tid spiser miden

Tjek om miderne spiste af pupperne

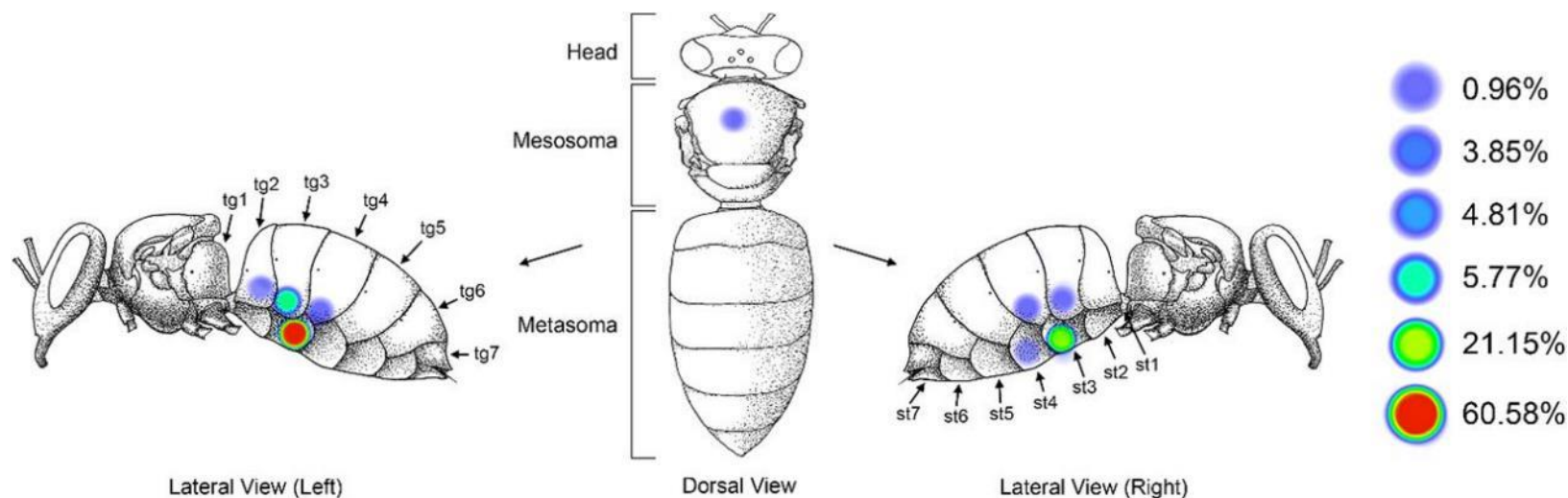
-indsprøjtning af fluorescerende kugler



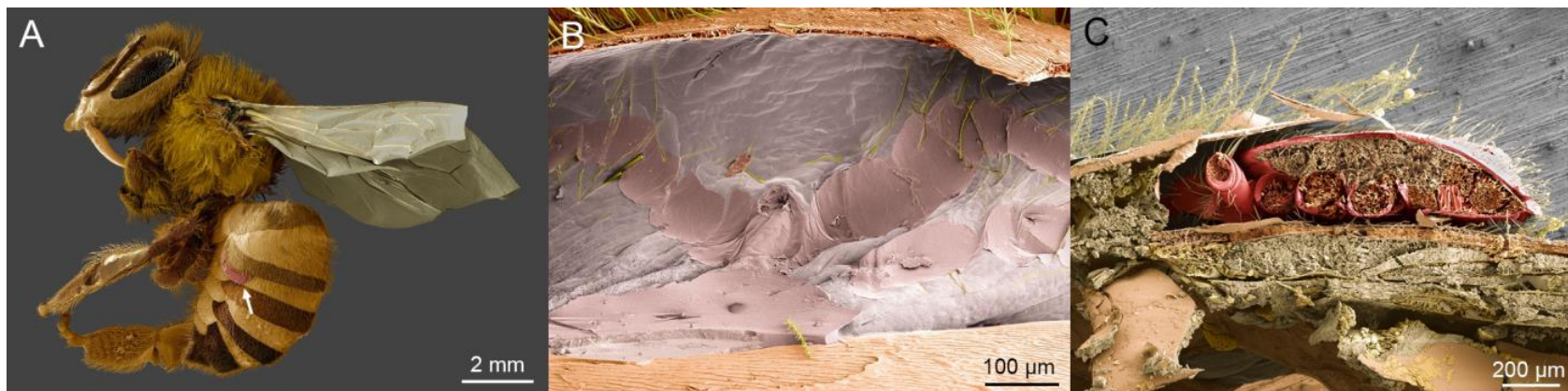
Varroa på voksne bier



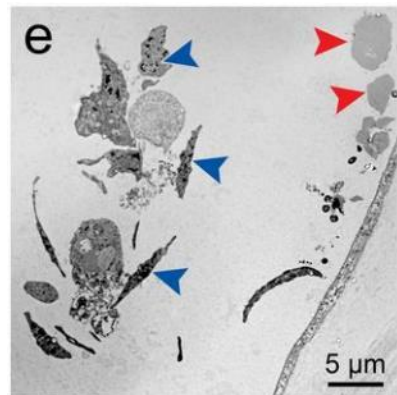
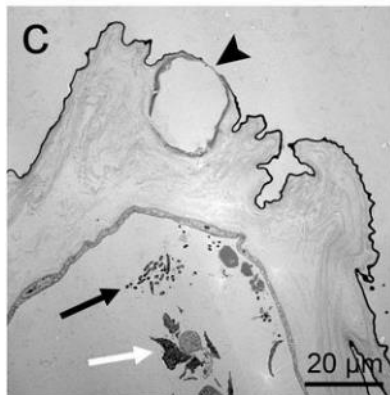
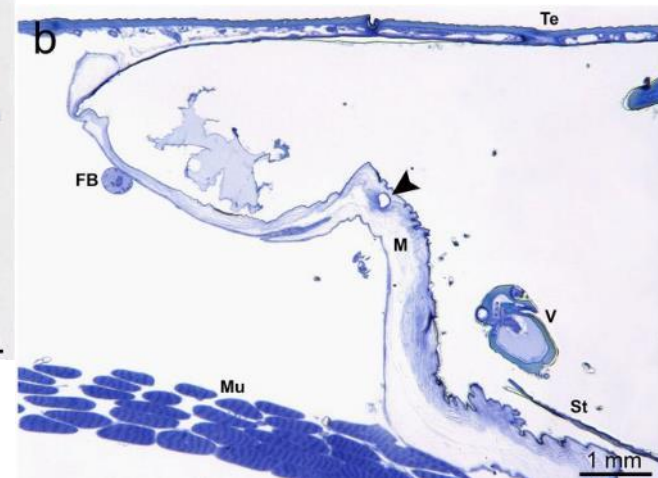
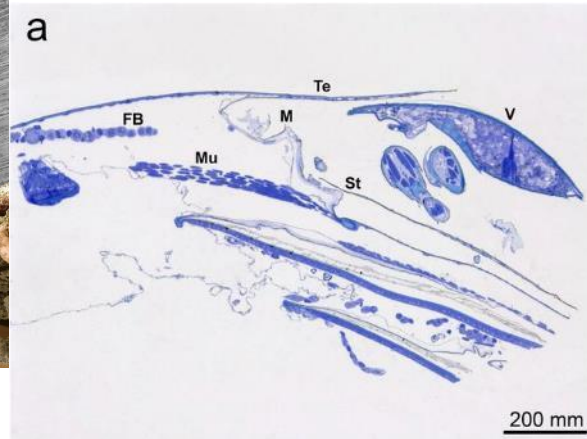
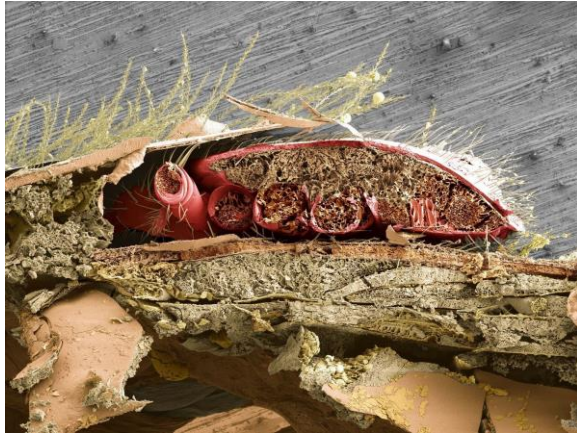
Varroa foretrække det 3. segment på voksne



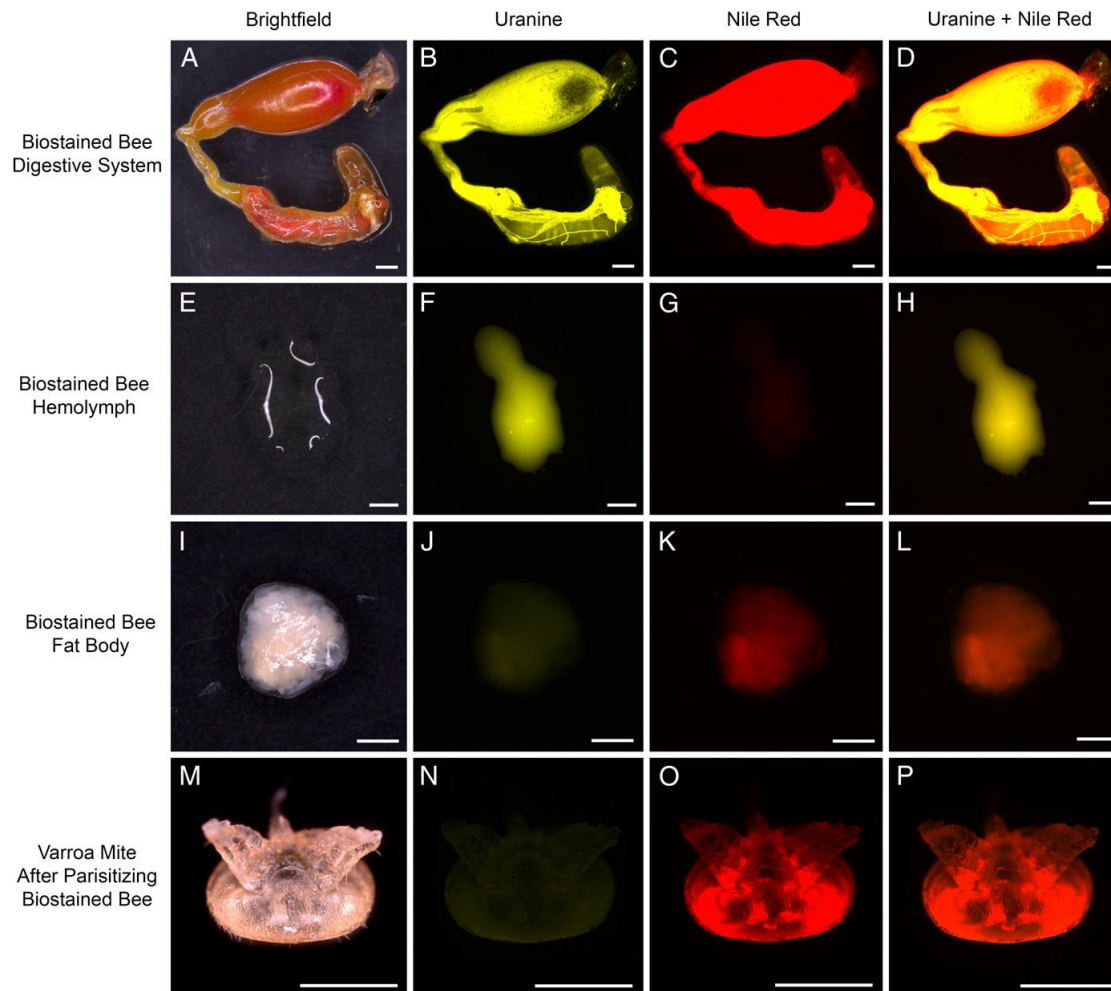
3. segment er det længste, og der er mere mavefedt lige under det ydre skelet.



Varroa ødelægger fedtlegemerne efter få timer



Fluorescerende farvning af voksne biers fedtvæv og varroamider



Varroa lever længer og producere flere æg på bi-fedt end blod

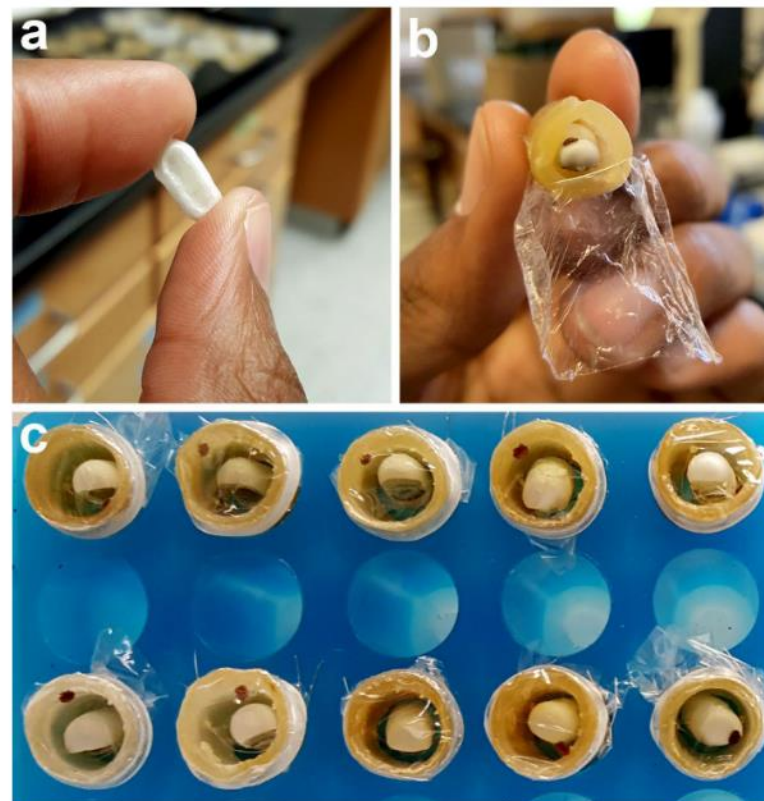
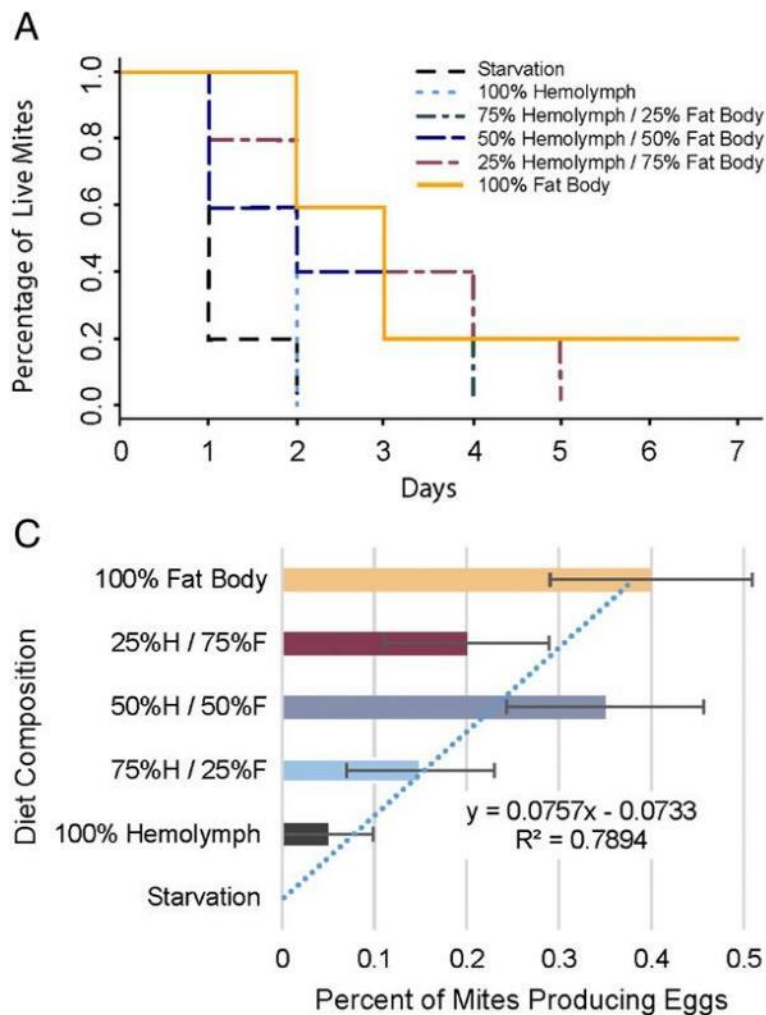


Fig. S4. In vitro *Varroa* mite rearing system used to feed mites a controlled diet of specific honey bee tissues. Decoy brood was composed of a gelatin capsule with a section cut away and replaced with a layer of parafilm stretched to 15µm in thickness (a, b). Enclosure made of compressed bees wax with transparent clingwrap used as cell capping (b, c).

Nyeste viden om varroas føde og føde søgning

- Hunmiden laver blivende huller i den ydreskelet af både voksne bier og pupper.
- Hunmiderne laver fødehullerne nogle bestemte steder – både på larver, pupper og voksne bier
- Hvis flere hunmider inficere en yngelcelle vil de ofte dele fødehul, men kan også lave flere. Jo flere hunmider jo flere huller.
- Der er i forhold til længden af midernes måltid er der en positiv sammenhæng mellem midernes sult (tid fra sidste måltid), men en negativ sammenhæng med svælgets pumpebevægelser.
- Hunmiderne lever ikke kun af biernes blod – de opløser fedtlegemerne og optager det.

Varroas direkte effekt

Vægt og væsketab

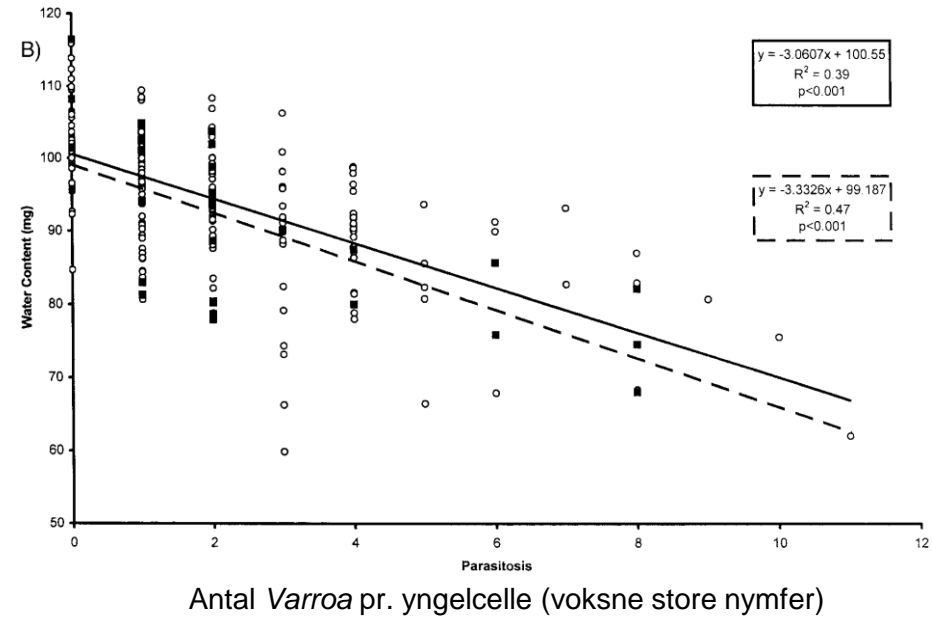
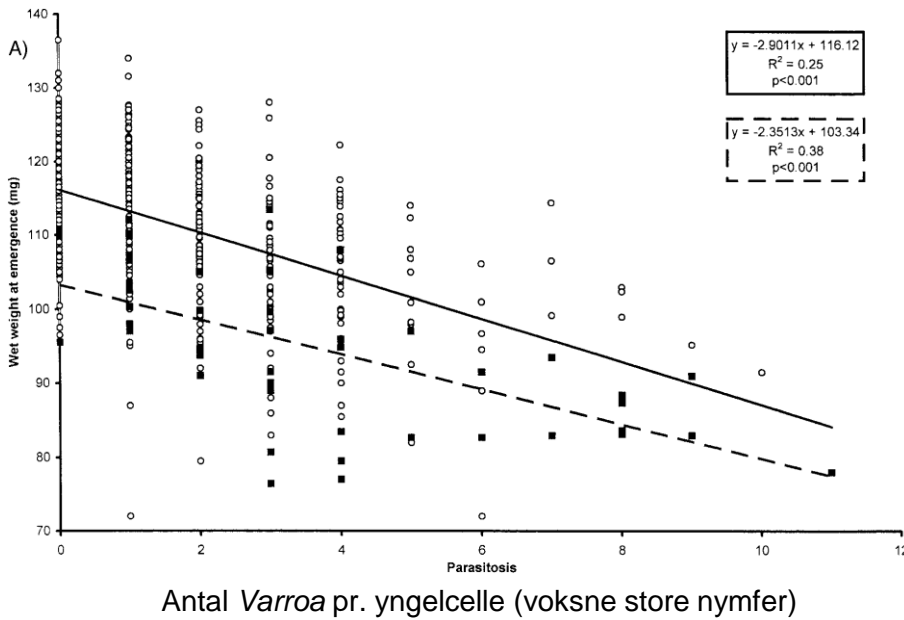
Kortere levetid,

Nedsætte immunsystemet

Nedsætter evnen til at håndtere
pesticider

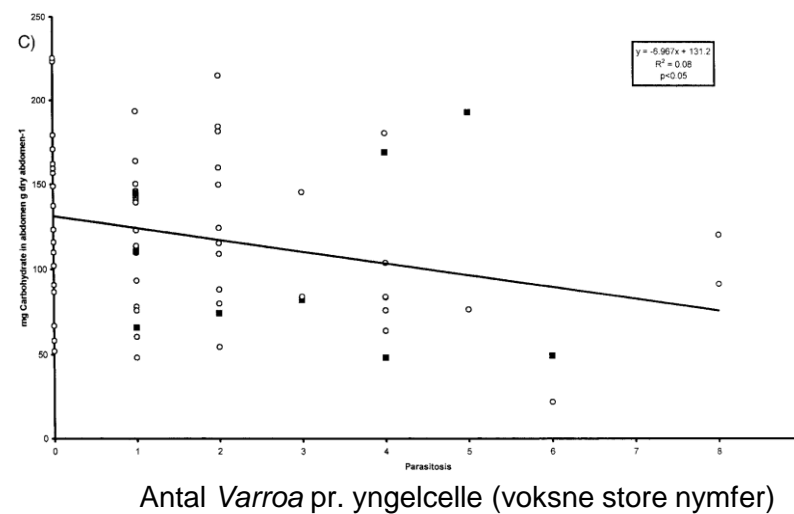
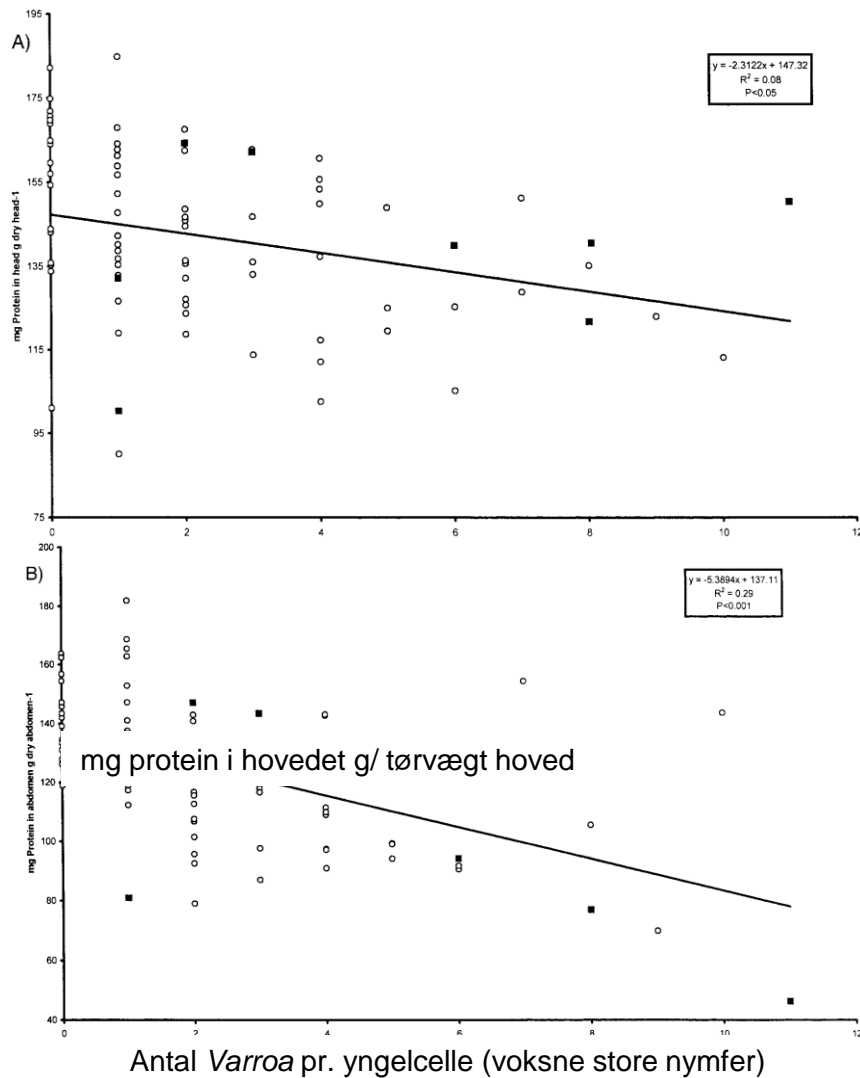


Flere mider i yngelcellerne giver mindre bierne



○ = Non-deformed bees; ● = Deformed bees.

Og mindre protein og kulhydrat i bierne



Og mindre mængde hemolymfe

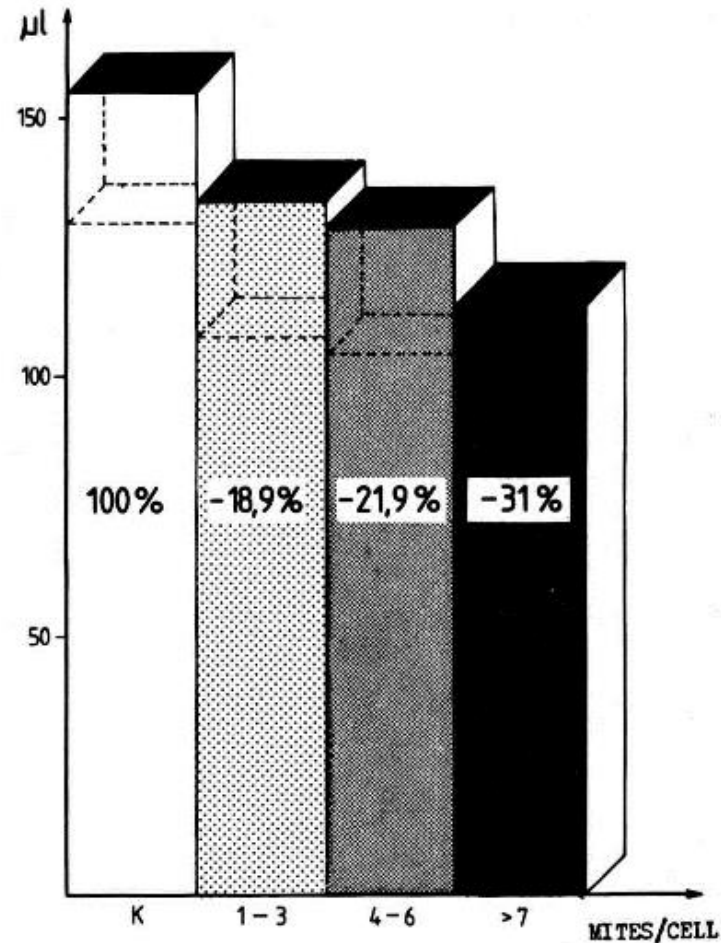


FIG. 8. — Haemolymph volume (μl) in drone pupae with brown eyes in relation to the infestation rate

Nedsat flyvekapacitet af droner

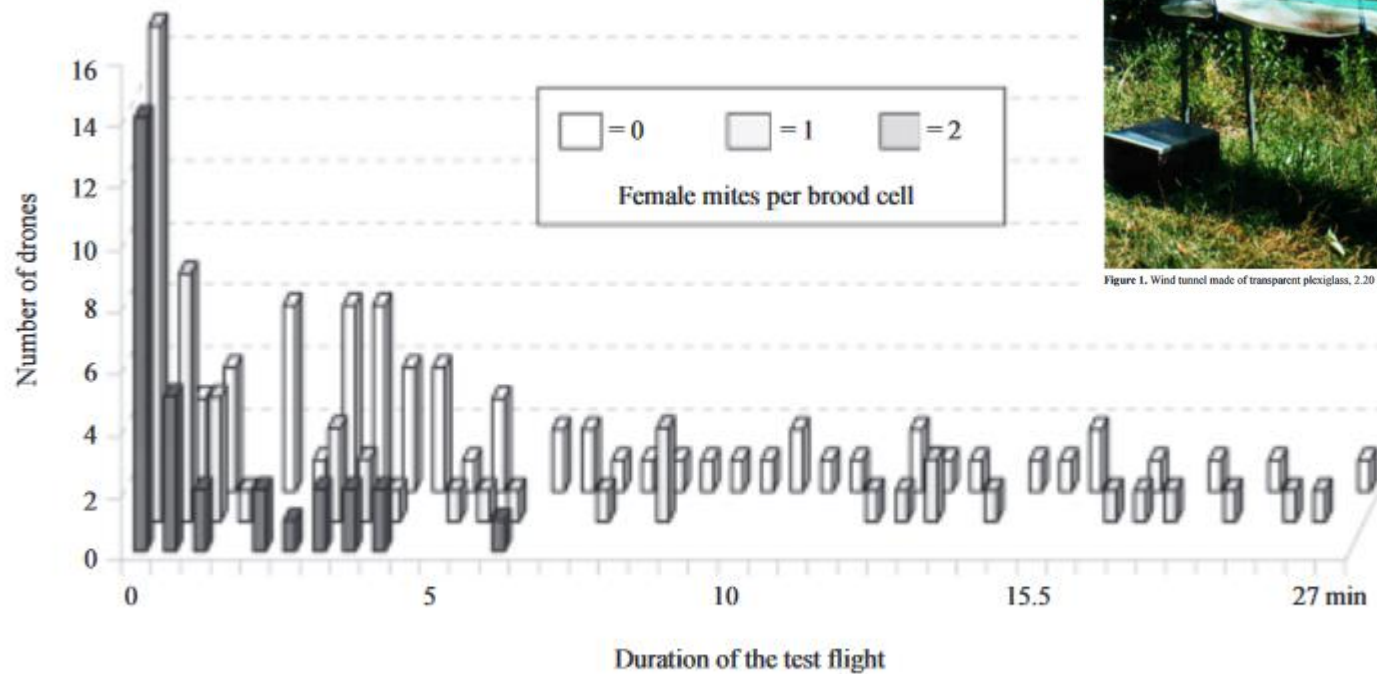


Figure 1. Wind tunnel made of transparent plexiglass, 2.20 m long with 0.42 m in inner diameter, with a fan at one end.

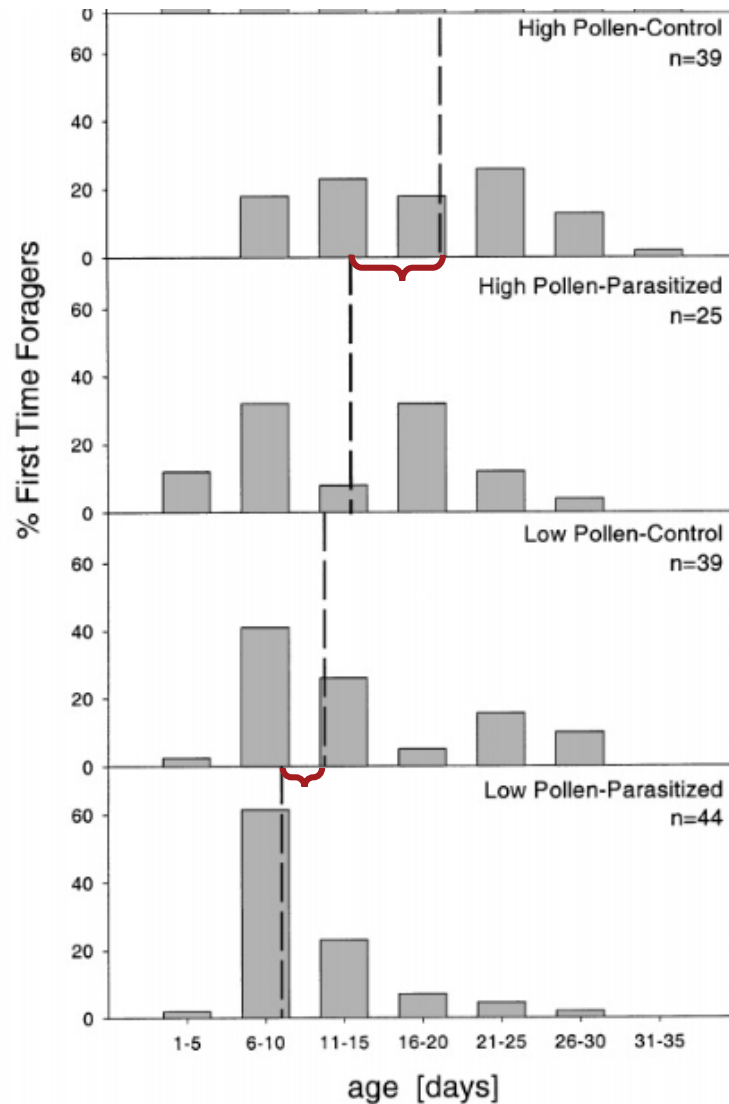
Figure 2. Relation between flight performance and pupal parasitic load in drones.

Nedsat sædproduktion

Table 1. Flight performance and sperm production of drones in relation to the level of pupal infestation by *Varroa destructor*. Mean values, m = median, SD = standard deviation, r = range, d = diminished in relation to the controls.

Degree of pupal infestation of the drones	Duration of the test flights	Number of spermatozoa
Unparasitized	N = 64. \bar{x} = 6'48" m = 4'54" SD = 5'35" r = 0'09" - 27'27"	N = 68 \bar{x} = 7,540,441 m = 7,475,000 SD = 2,812,780 r = 2.5 x 10 ⁶ - 12.8 x 10 ⁶
One female mite per brood cell	N = 37 \bar{x} = 6'55" m = 5'02" SD = 6'40" r = 0'15" - 22'15"	N = 53 \bar{x} = 5,734,623 m = 4,200,000 SD = 3,574,404 r = 1 x 10 ⁶ - 13.5 x 10 ⁶ d = -24%
Two female mites per brood cell	N = 16 \bar{x} = 2'16" m = 2'27" SD = 1'40" r = 0'09" - 6'01" d = -67%	N = 31 \bar{x} = 4,192,258 m = 3,550,000 SD = 2,506,754 r = 1 x 10 ⁶ - 9.5 x 10 ⁶ d = -45%

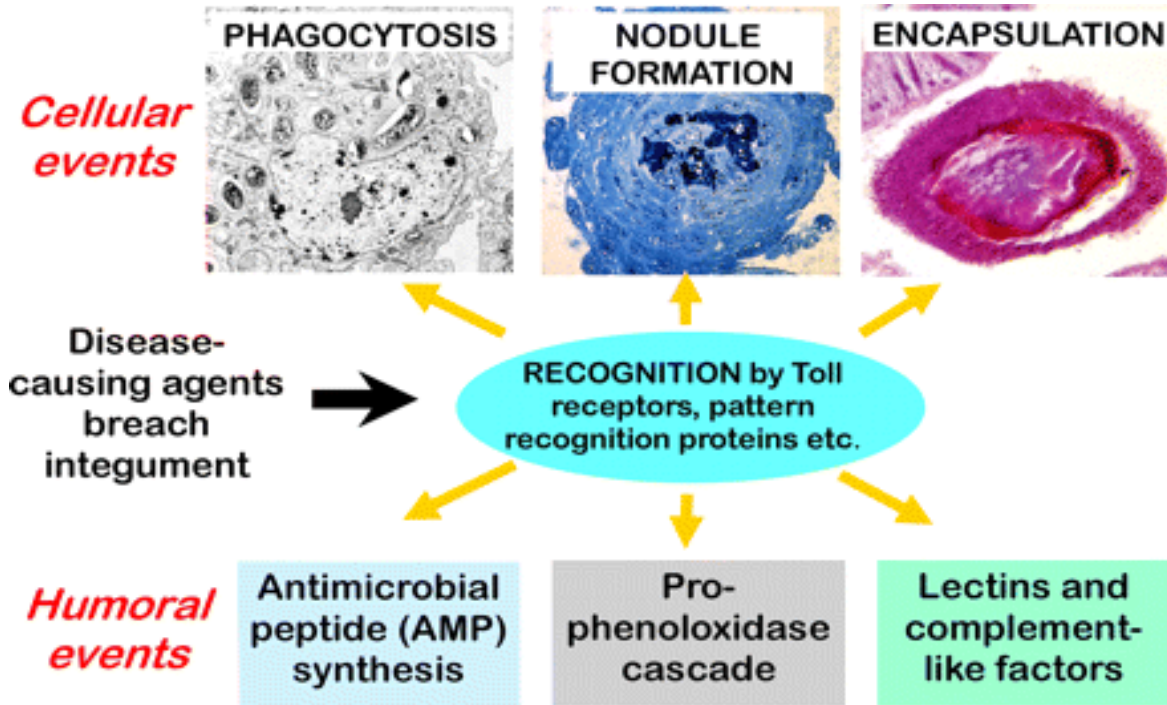
Varroa gør bierne ældre - fra stade til trækbiere



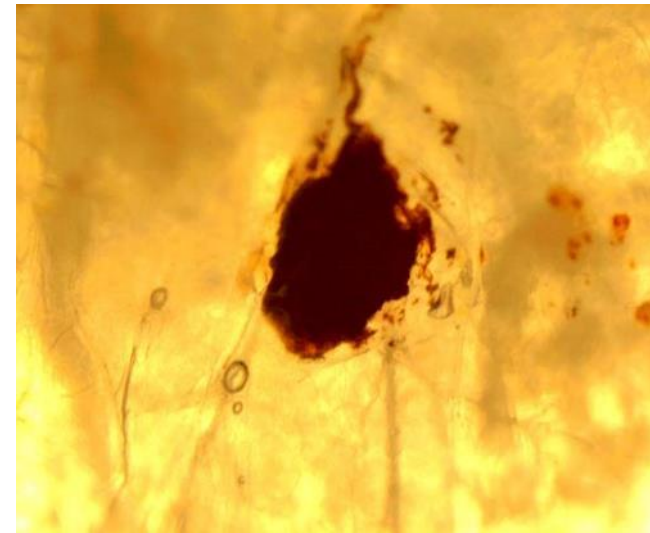
Især når pollen forsyningen er høj

Janmaat and Winston 2000

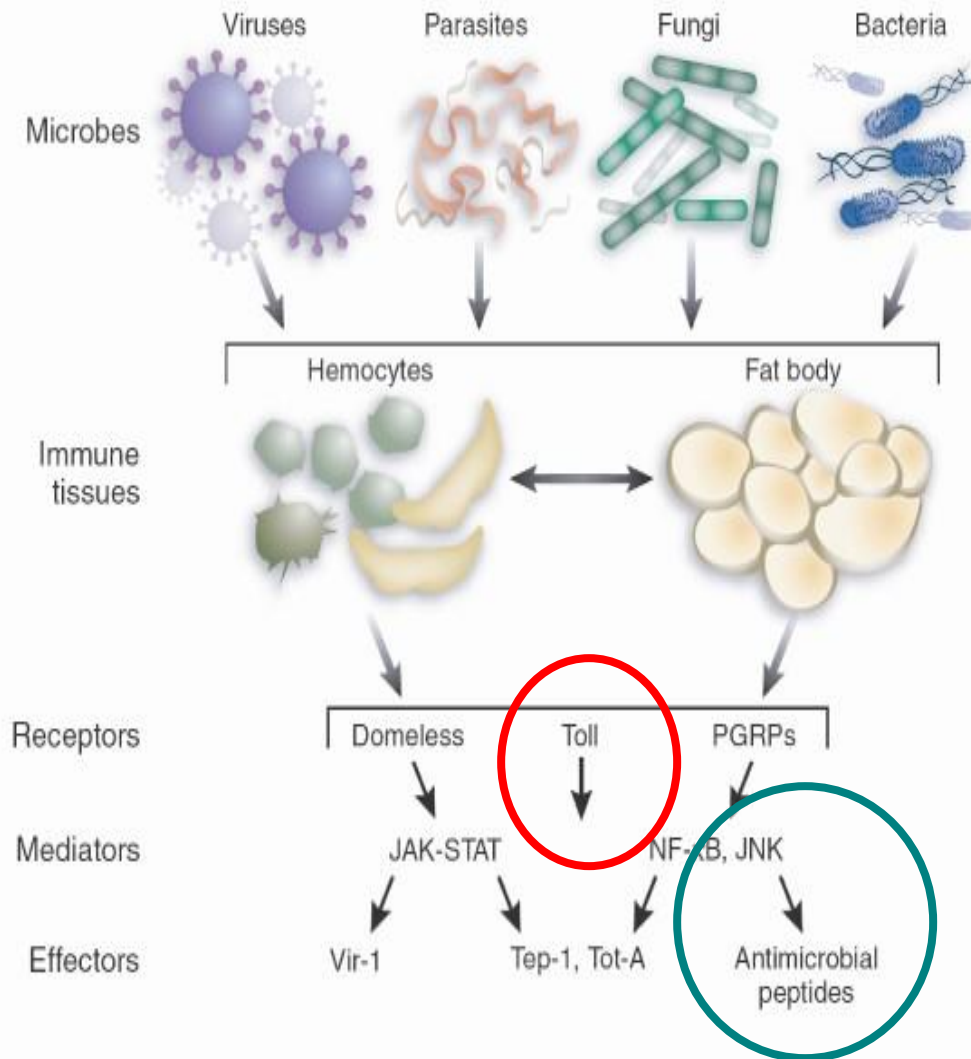
Insect Immune Responses



Melanotic shield



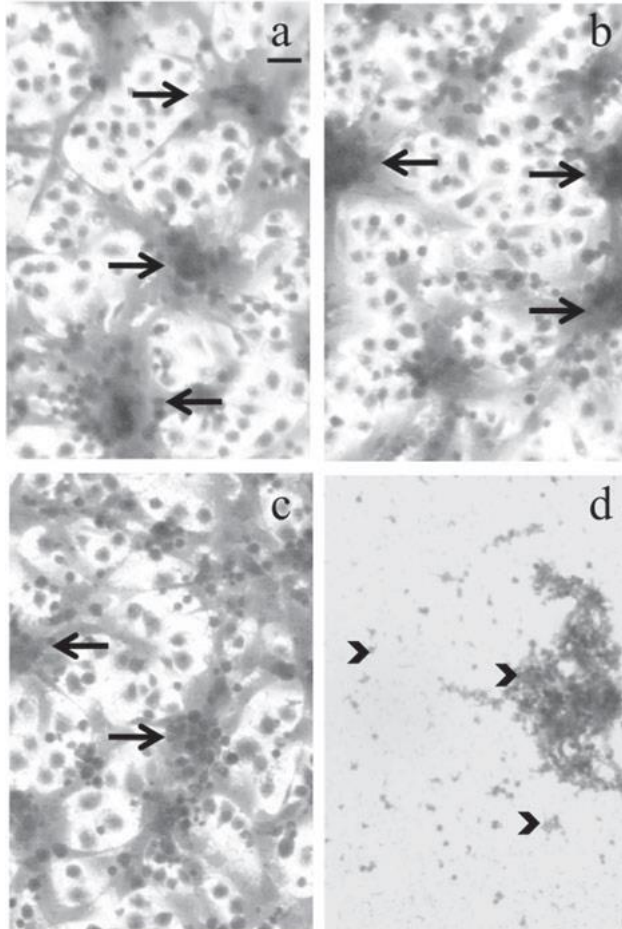
Insect defenses



AMPs: Defensins, apidaecin and abaecin, apisimin, hymenoptaecin

Katie Ris

Varroas spyt forhindre insekternes hemocytter i at samle sig



Hemocytes were incubated for 18 h with either eludates from

- (a) only a cotton wool ball
- (b) CWB – mites + pilocarpine
- (c) CWB + mites - pilocarpine
- (d) CWB + mites + pilocarpine

Opregulering af nogle gener i larvestadiet men nedregulering i pupper

Table V. Summary of significant changes in worker and drone broods infested with *Varroa* relative to non-infested workers and drones at the same developmental stage

Gene name	Stage				
	L5 Workers Drones	PP Workers Drones	P3 Workers Drones	P5 Workers Drones	I Workers Drones
Genes in the extracellular domain of the Toll pathway					
<i>PGRP-S2</i>		■		■	
<i>PGRP-S3</i>	■	■		■	■
<i>TLR</i>	■				■
Genes in the cytoplasmic domain of the Toll pathway					
<i>MyD88</i>	■		■		
<i>pelle</i>	■			■	
<i>tube</i>	■		■		■
<i>cact-1</i>		■		■	
<i>cact-2</i>	■	■	■	■	■
Nuclear localization signal					
<i>dorsal-1A</i>	■			■	■
<i>dorsal-2A</i>	■	■	■	■	■
AMP effector genes					
<i>hymenoptaecin</i>				■	■
<i>abaecin</i>				■	■
<i>defensin-1</i>	■	■	■	■	■
<i>defensin-2</i>	■	■	■	■	■

Up-regulation
 Down-regulation
 No change

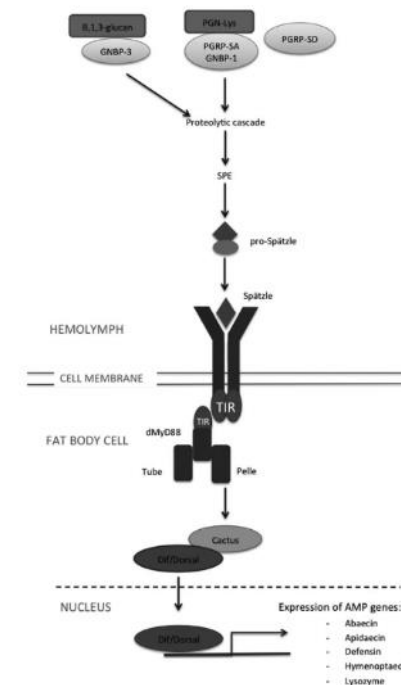
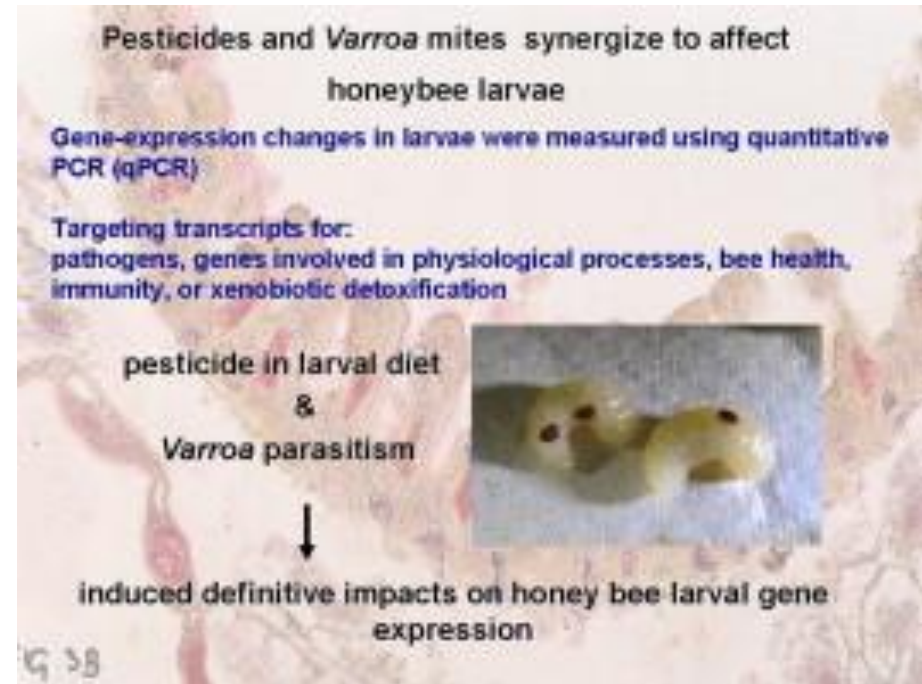
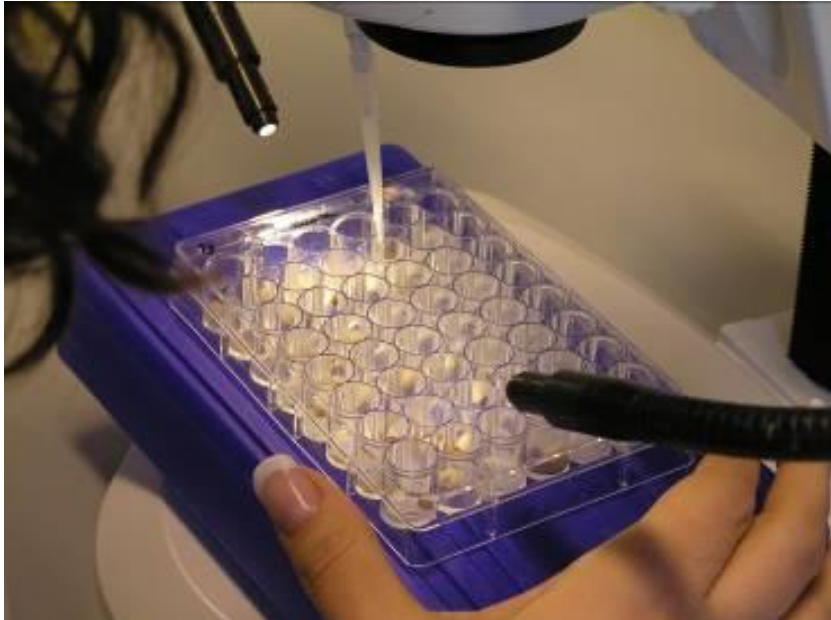


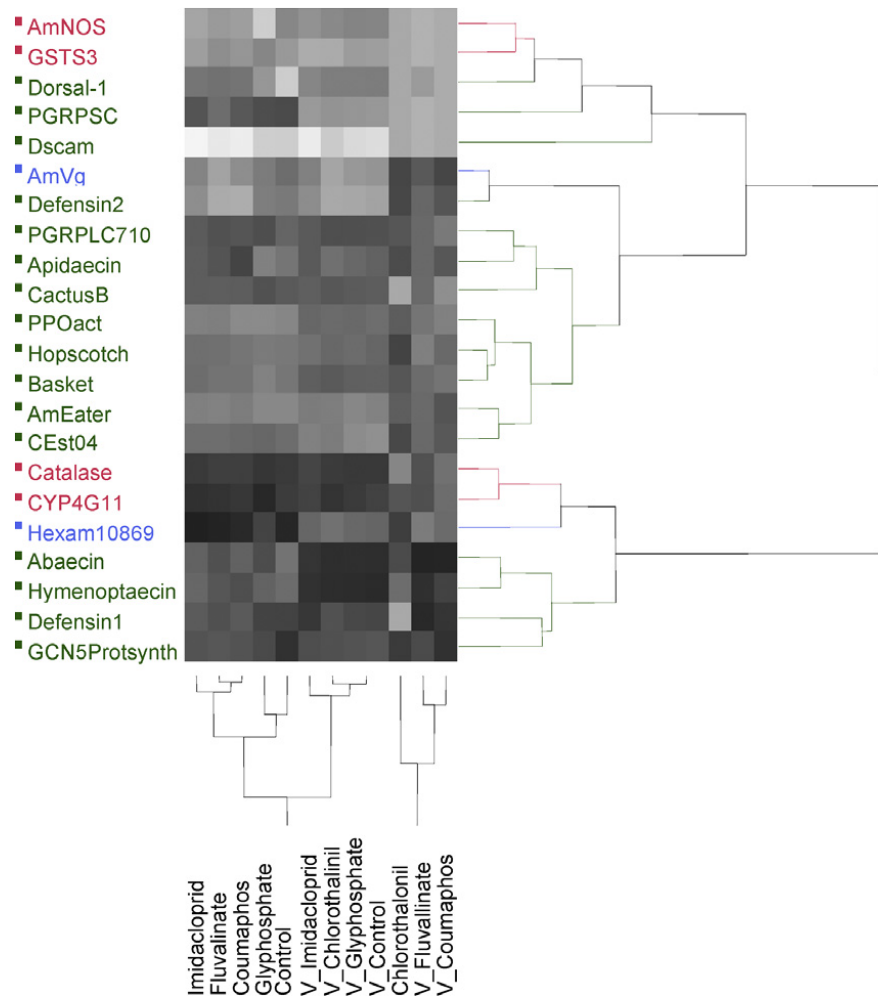
Fig. 1. Model of Toll pathway activation (based on figure from Lemaitre and Hoffmann 2007)

Varroa og pesticider ændre gen-ekspressionen

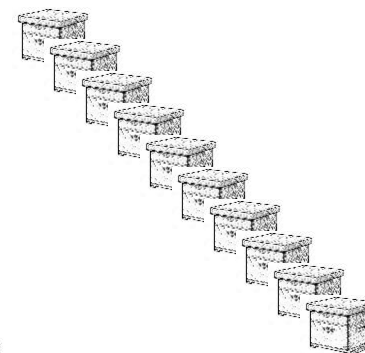
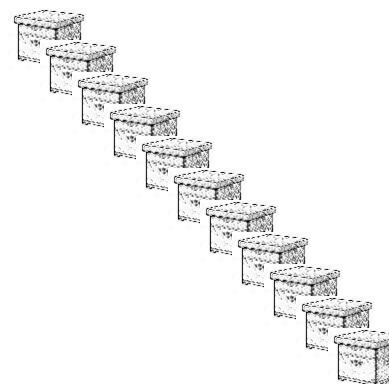
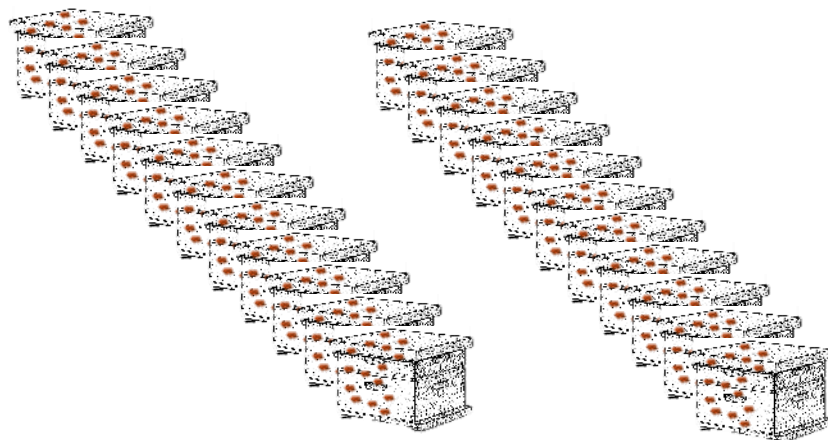


Varroa og pesticeder ændre gen-ekspressionen

stress responses (rød)
 immune traits (grøn)
 udviklings traits (blå)



Varroa gør bier mindre tolerant over for pesticider...de flyver dårligere med begge stress faktorer

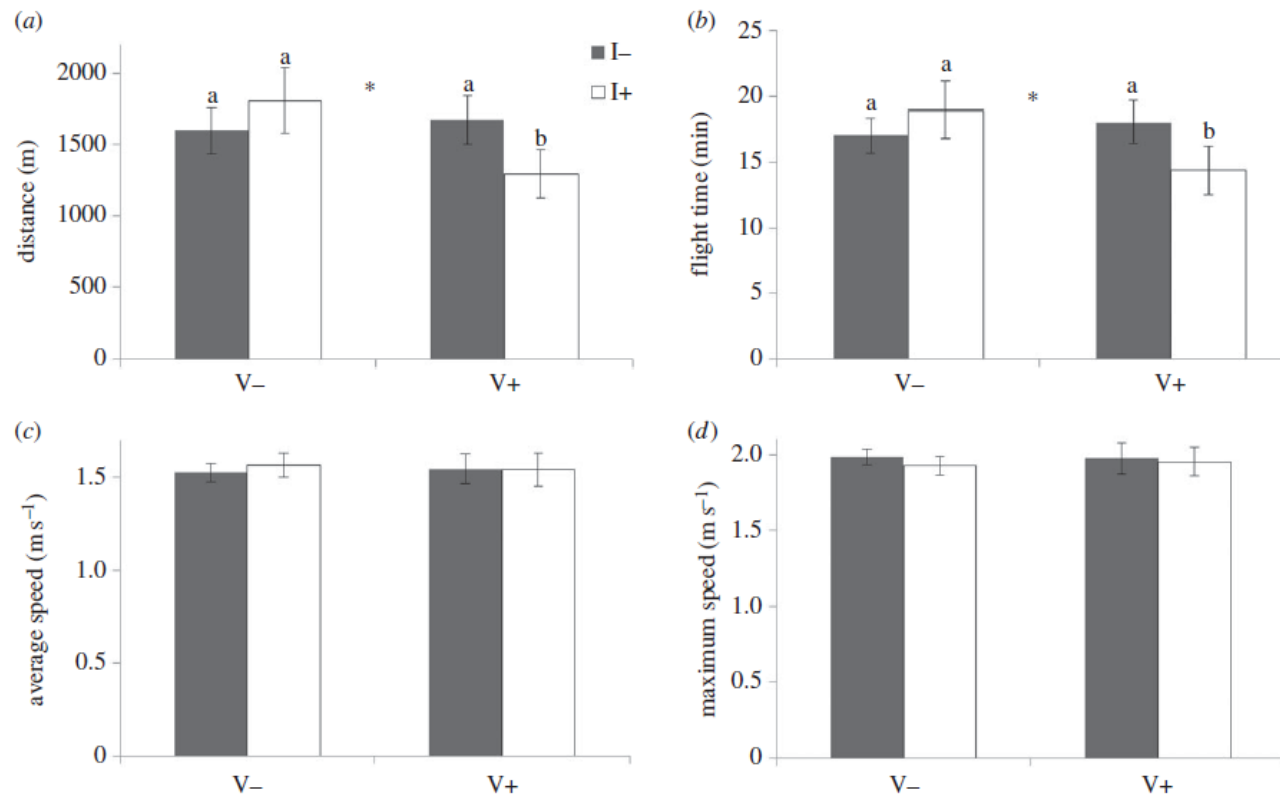


2 x 10 kolonier blev Varroa-behandlet
 2 x 10 kolonier fodret med subletale koncentrationer af imidacloprid (neonicotinid)



Figure 4. Wind tunnel study of neonicotinoid toxicity. 20 bees were tested in the wind tunnel with a flow of 1 m/s.

Varroa gør bier mindre tolerant over for pesticider...de flyver dårligere med begge



Viden om varroas direkte effekt – uden virus

- De meste er på basis af ældre litteratur – nu inkluderes virus ofte
 - Den største effekt ses når bierne parasiteres i yngelcellerne
 - Der ses større effekter når der er flere hunmider i en celle
 - Der er vægt og væsketab
 - Flyver dårligere
 - Biernes ældes hurtigere – og lever kortere
 - Nedsat immunforsvar
-
- Stresses de samtidig af andre ting, dårlig pollenforsyning, pesticider eller andre patogener ses ofte tydeligere effekter

