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Insect diseases and their use in biological control of pest insects

Rudolf Wegensteiner
Department of Forest and Soil Sciences
Institute of Forest Entomology, Forest Pathology and Forest Protection
University of Natural Resources and Applied Life Sciences, BOKU Vienna

Biological control …

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- Natural enemies acting in pest-populations as **regulators**

⇩

- Use of natural enemies in **biological control**

Methods in biological control:

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- „Classical“ biological control
- „Neo-classical“ biological control
- „Conservation“ biological control

- Inoculative release
- Inundative release

Eilenberg et al. 2001, modified

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- Predators
- Parasitoids
- Pathogens

Pathogens in Insects

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Virus

Bacteria

Fungi

Microsporidia

Virus

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intracellular development (in cytoplasm or in nucleus) =
obligate pathogen ⇨ death of infected cells

Photo: SIP

Bacteria

Bacillus thuringiensis (Bt)

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extracellular development = facultative pathogen; Bt-spore + parasporal crystal ⇨ intoxication of midgut epithelium ⇨ septicemia

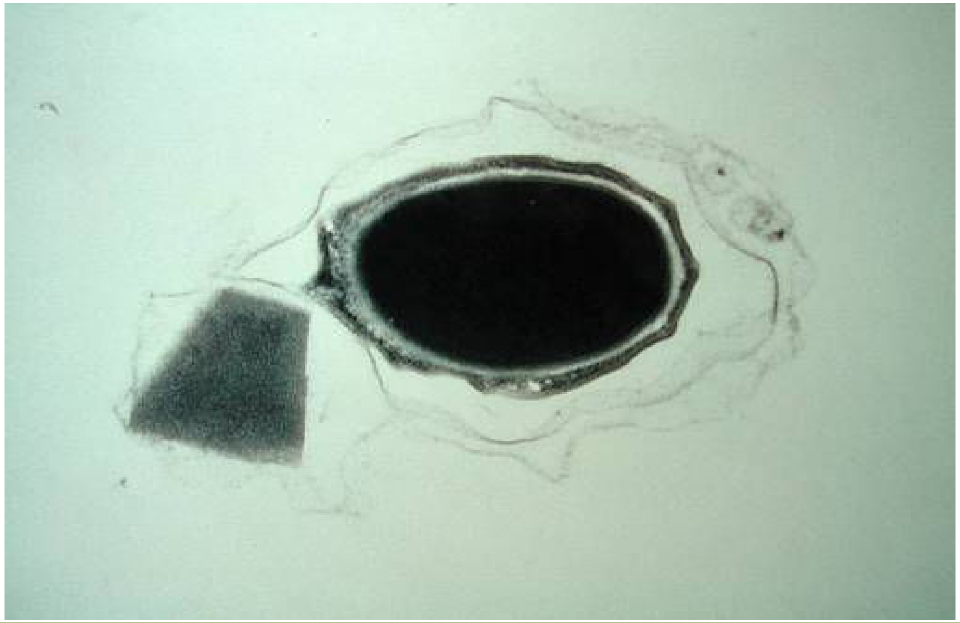

Photo: SIP

Fungi

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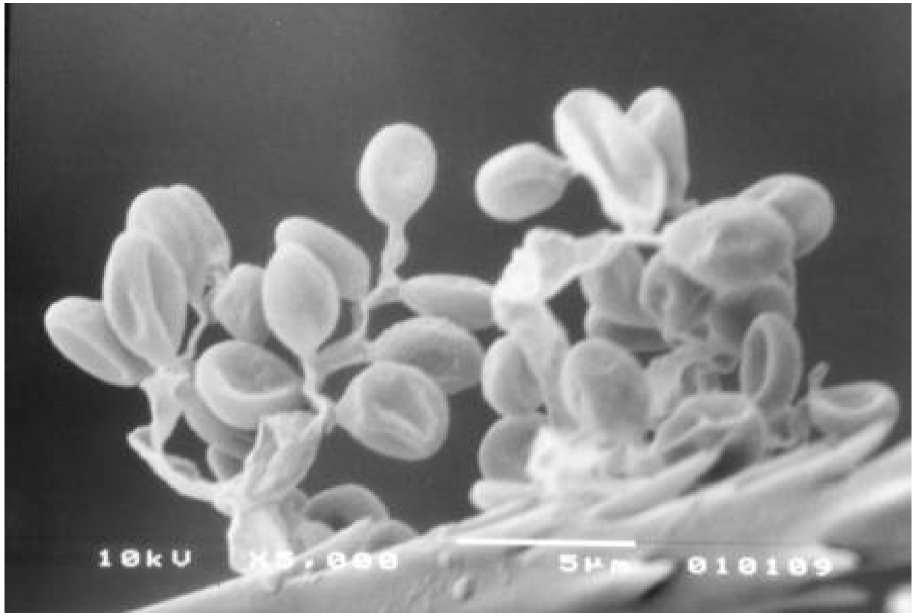
extracellular development = facultative pathogen ⇨
metabolites and mechanical destruction of organs



Microsporidia

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intracellular development = obligate pathogen ⇨ death of infected cells

Photo: SIP

Transmission of pathogens

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- horizontal:
  between individuals of the same generation,
  e.g.: ingestion of occlusion bodies or spores together with food (virus, bacteria, microsporidia) or inoculation via cuticle (fungi)
- vertical:
  from parental-individuals to offspring-individuals (trans-ovum)

Examples for successful use of microbials

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- *Lymantria dispar*
- *Melolontha melolontha* and other Scarabaeidae
- *Oryctes rhinoceros*
- *Locusta migratoria*

Lymantria dispar

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Lymantria dispar (Gipsy moth)

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Geographical distribution (originally):

In Europe and Asia:

- in the North: England, S-Sweden, Sibiria
- in the South: N-Africa, Syria, Georgia, S-China.

Feeding of all larval instars in favor on *Quercus* spp.

Outbreaks in Europe: approx. 10- to 30- years interval – in most cases of local importance, only a limited time period (⇨ lack of food, natural enemies, ...).

Lymantria dispar (Gipsy moth)

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1869 „introduction“ of this species by L. Trouvelot to North-America

starting in 1889 with permanent dispersion in

East-USA and East-Canada

polyphagous on broad-leaf trees!

Insufficient natural enemy complex.

Lymantria dispar control in USA

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- insufficient control using Arsenic-preparations, DDT, Carbaryl and Pyrethroids
- good control using *NPV*-preparation;
- good control using *Bt*-preparations;
- good and sustainable control using *Entomophaga maimaiga*

NPV

Btk

E. maimaiga

Photos: SIP

Lymantria dispar + NPV

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Lymantria dispar + *Entomophaga maimaiga*

Photo: SIP


M. melolontha

Entomopathogenic fungus: *Beauveria brongniartii*

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- Conidiospores attach to the cuticle – germ penetrates the integument into haemocoel – development in the host – after host's death – penetration of integument to the outside and formation of conidiospores.
- Adults and larvae are sensitive.
- Inoculative release of fungal material by dissemination into soil.
- Relatively rapid action and persistence.
- Mass production is easy.

Melolontha melolontha + *Beauveria brongniartii*

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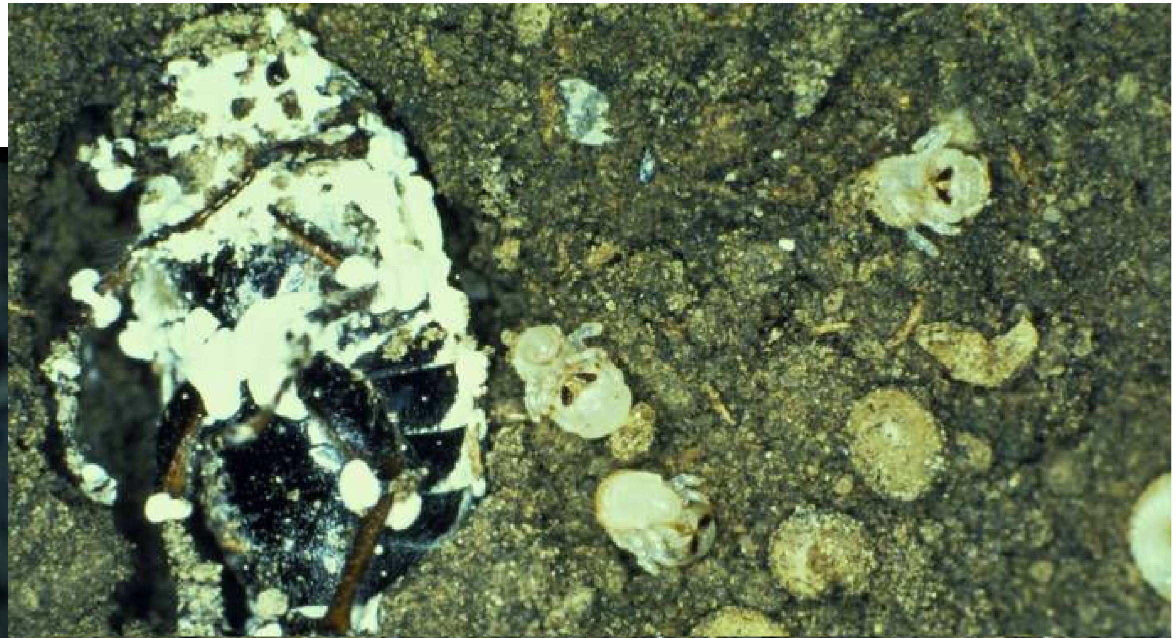
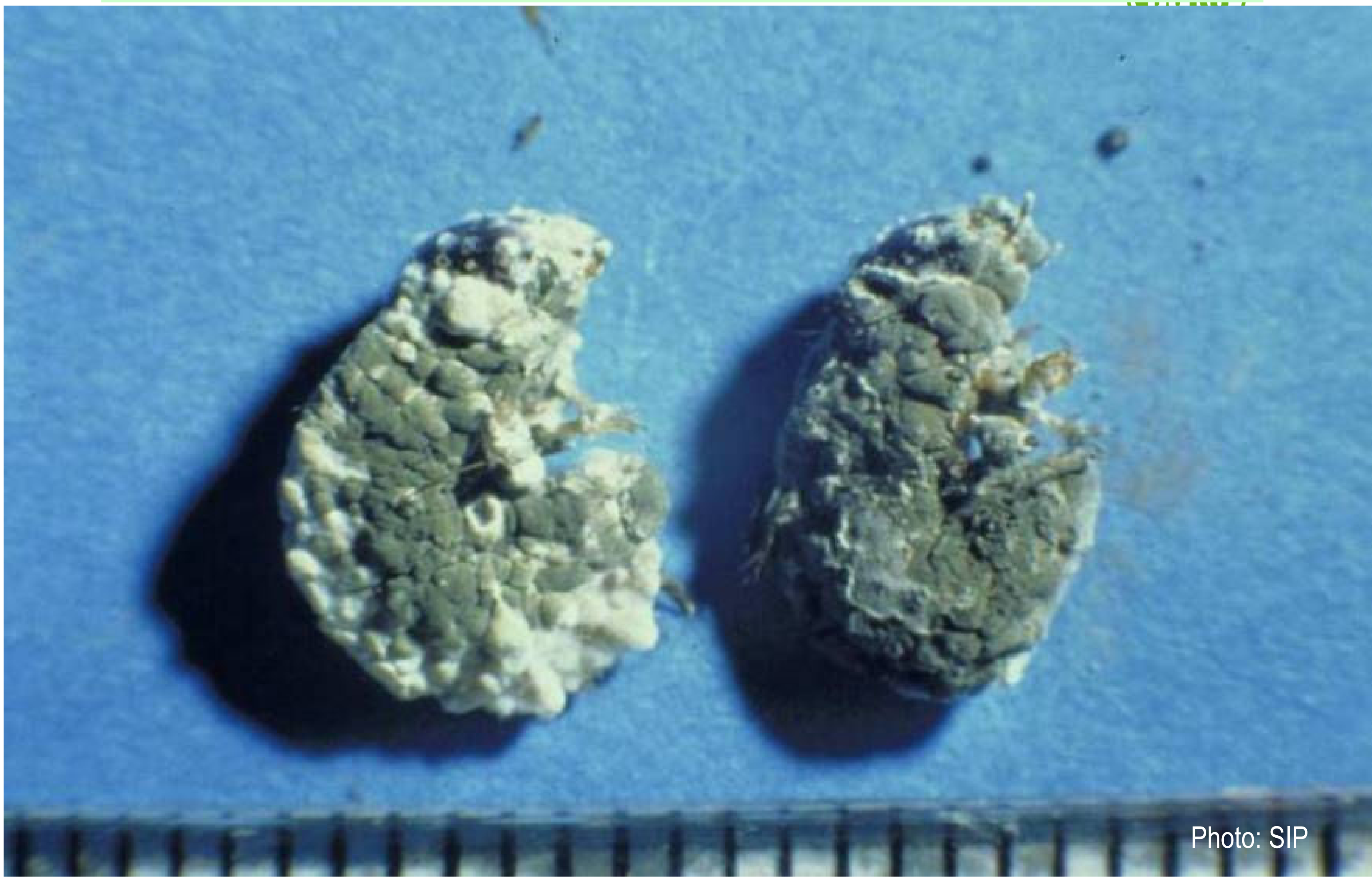
Beauveria brongniartii



Photos: S. Keller

Metarhizium anisopliae infecting larvae of Scarabaeidae



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Oryctes rhinoceros
(Coconut palm rhinoceros beetle)

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- Adult beetles are mining in the vegetative cones of palm trees

- Larvae develop in decomposing palm trunks or other palm slash

in indo-pacific area ⇨ great problems in control

Oryctes rhinoceros

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Pathogens in *O. rhinoceros*

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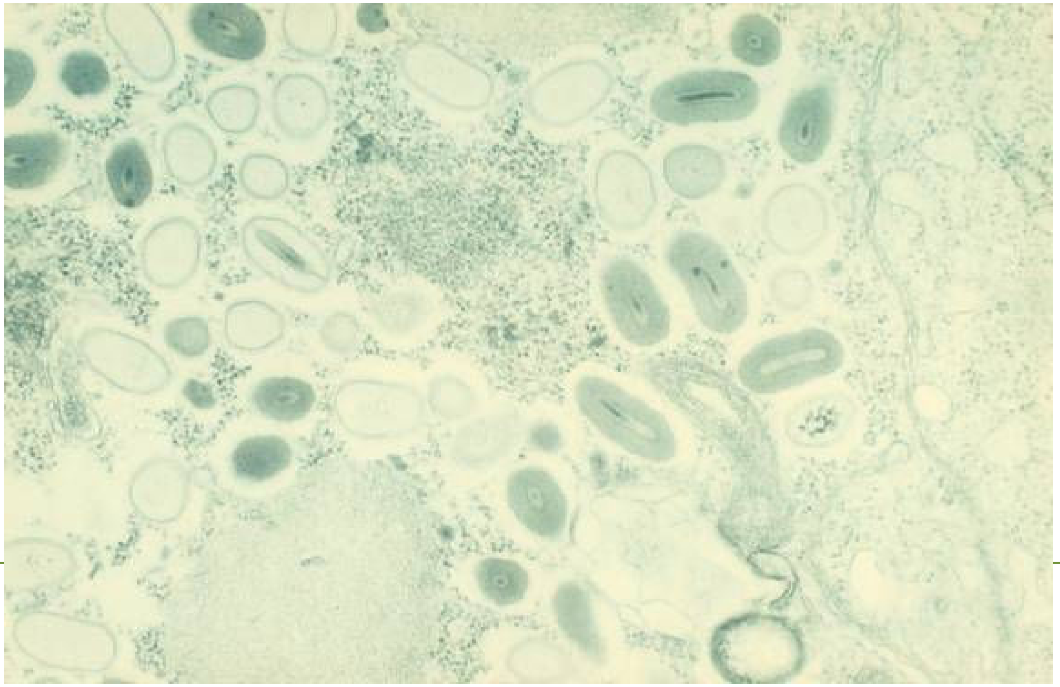
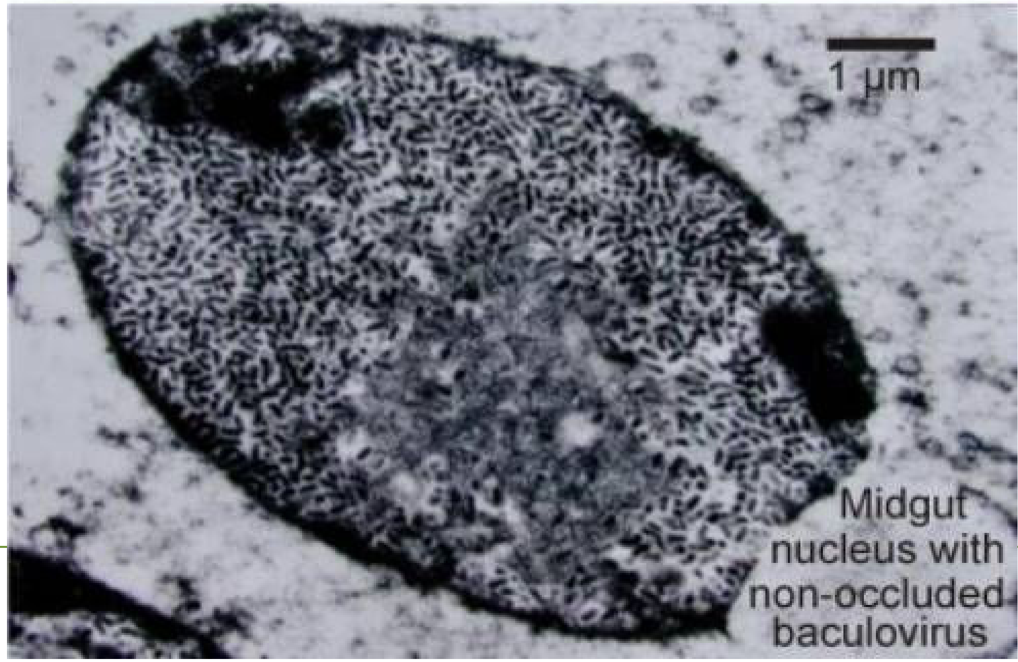
- **Virus** disease found in Malaysia, first in larvae, later in adult beetles (Huger, 1963):
  Baculovirus type C ("Oryctes-Baculovirus"), without "occlusion bodies"! expression and reproduction in nucleus





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Baculovirus in *O. rhinoceros*

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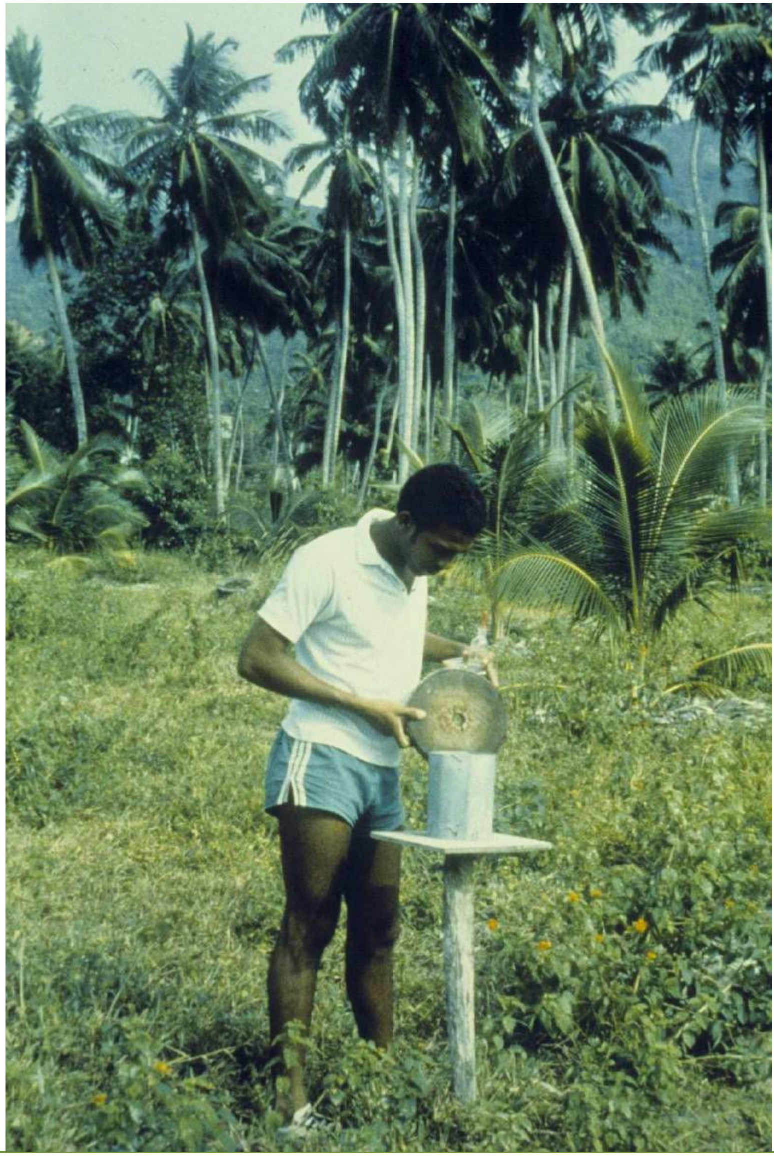
- Larvae and adults are sensitive to this virus infection; dispersal mainly by adults.
- Horizontal and vertical transmission.
- After infection with virus – stop feeding, but chronical course of disease (at the beginning no influence on migration!).
- “Inoculative release” of virus.
- Mass production “in vivo” or in cell lines.

Aggregation pheromone: "Oryctalure"



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Feeding virus suspension

Photos: SIP

Entomopathogenic fungus in *O. rhinoceros*

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- **Fungal** disease: *Metarhizium anisopliae*

  Form conidiospores on surface of cuticle – percutaneous infection ⇨ penetration of integument ⇨ colonisation of the whole individual ⇨ after host's death: penetration of the integument to the outside and formation of conidiospores.

Metarhizium anisopliae in *O. rhinoceros*

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- larvae and adults are sensitive to this fungal infection- horizontal and vertical transmission (percutan).
- Relatively rapid action.
- Easy to introduce by spraying breeding habitat.
- Easy to multiply in/on artificial media.

<u>Orthoptera:</u>
Locusta migratoria

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Photos: FAO

solitary – gregarious status of population

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Pheromone governed:

- ”gregarisation“
- ”maturation“ – mature adults
- aggregation of females and egg laying

Photo: FAO

„hopper“

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Photos: FAO

„adults“

Metarhizium spp.

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- Conidiospores attach to the cuticle – germ penetrates the integument – fungus develops in the host – after host‘s death – penetration of integument to the outside and formation of conidiospores.
- Adults and larvae are sensitive: mainly spraying “hoppers” (cannot fly!).
- Mass production is easy.

Metarhizium flavoviride

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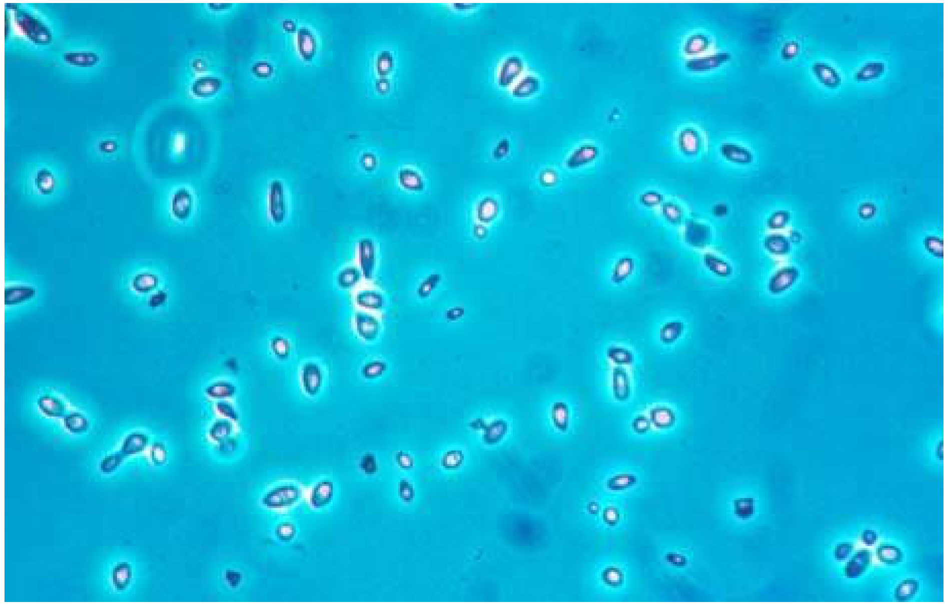

Metarhizium flavoviride and *M. anisopliae* var. *acridium*

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Further microbials ...

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- *Nosema locustae*
  - Attracting locusts by use of bran bait, loaded with spores of *N. locustae.*
  - *N. locustae* is a slow acting pathogen.
  - Significant reduction of feeding and egg laying.
  - Interruption of pheromone communication.
  - Mass production in living insects.

Nosema locustae

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- NOLO BAIT
  Nosema locustae,
  in combination with
  an attractant (bait)

Advantages of microbials:

- Microbial insecticides are non-pathogenic to wildlife and humans; their residues present no hazards to humans or other vertebrates; microbial insecticides can be applied even when a crop is almost ready for harvest.
- The pathogenic action of microbial insecticides is often specific to a single group or species of insects; this specificity means that most microbial insecticides do not directly affect beneficial insects.
- Some microbials can be produced easily (and inexpensive) even on a small scale basis.
- In some cases, the pathogenic micro-organisms can become established in a pest population or its habitat and provide control during subsequent pest generations or seasons.

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Disadvantages of microbials:

- Single microbial insecticides are pathogenic to only one species or group of insects, each application may control only a portion of the pests present in a field or forest. If other types of pests are present in the treated area, they will survive and may continue to cause damage.
- Heat, desiccation, or exposure to UV radiation reduces the effectiveness of several types of microbial insecticides.
- Special formulation and storage procedures are necessary for some microbial pesticides.
- Because several microbial insecticides are pest-specific, the potential market for these products may be limited.

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Vienna

Dr. Rudolf Wegensteiner

Gregor Mendel-Straße 33, A-1180 Vienna, Austria
Tel.: +43 1 3686352-30, Fax: +43 1 3686352-97
rudolf.wegensteiner@boku.ac.at, www.boku.ac.at