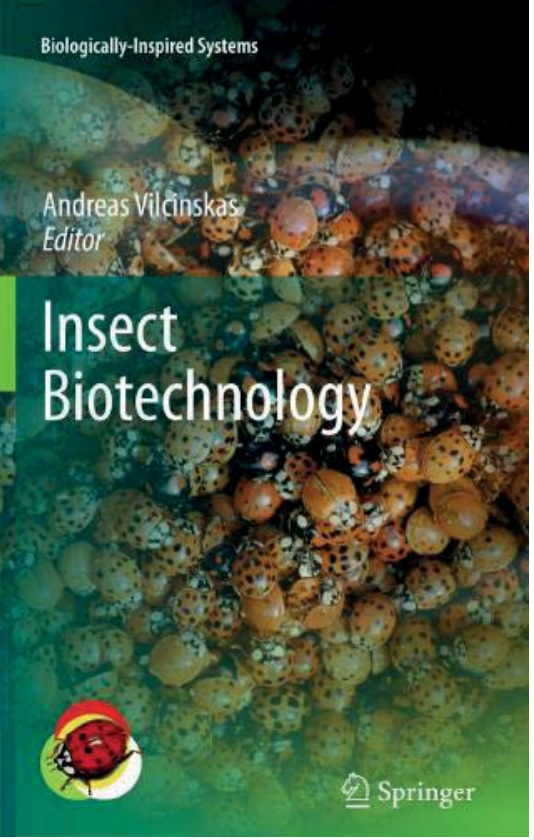
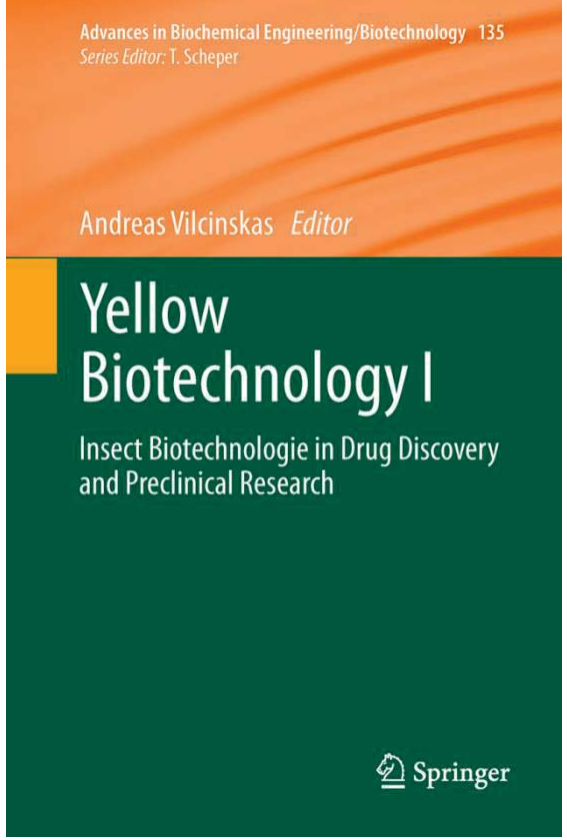
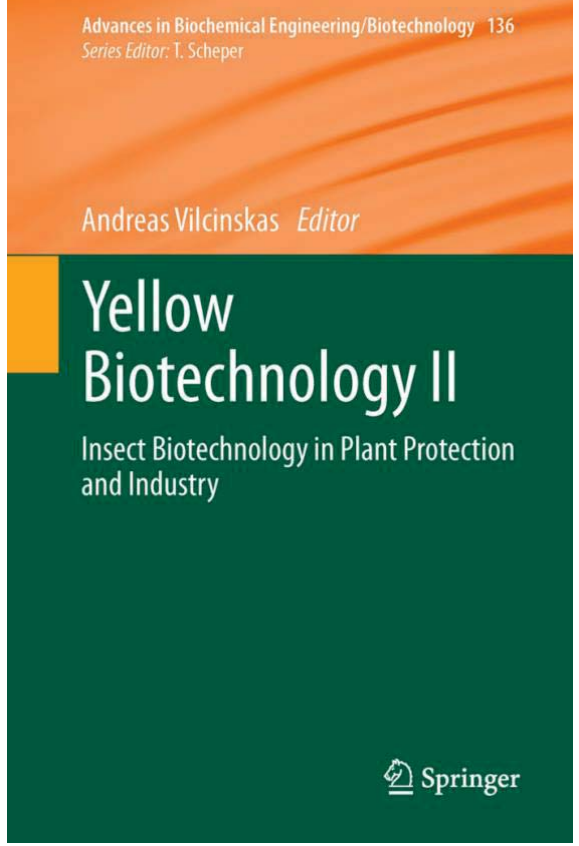






Insektenbiotechnologie im Pflanzenschutz

Andreas Vilcinskas

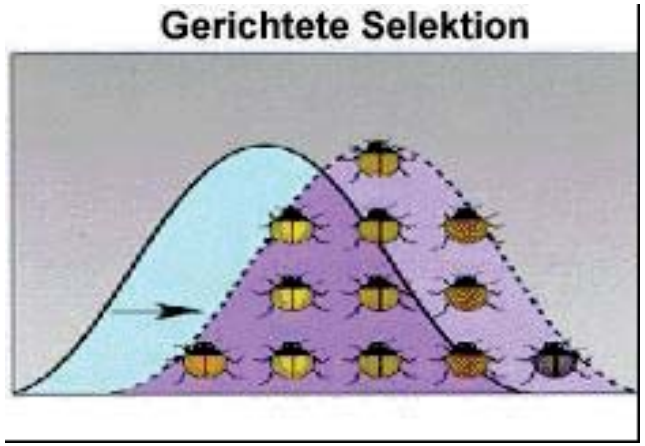
Institut für Insektenbiotechnologie, Justus-Liebig-Universität, Gießen
Fraunhofer Institut für Molekularbiologie und Angewandte Ökologie, Abteilung Bioressourcen,Gießen,

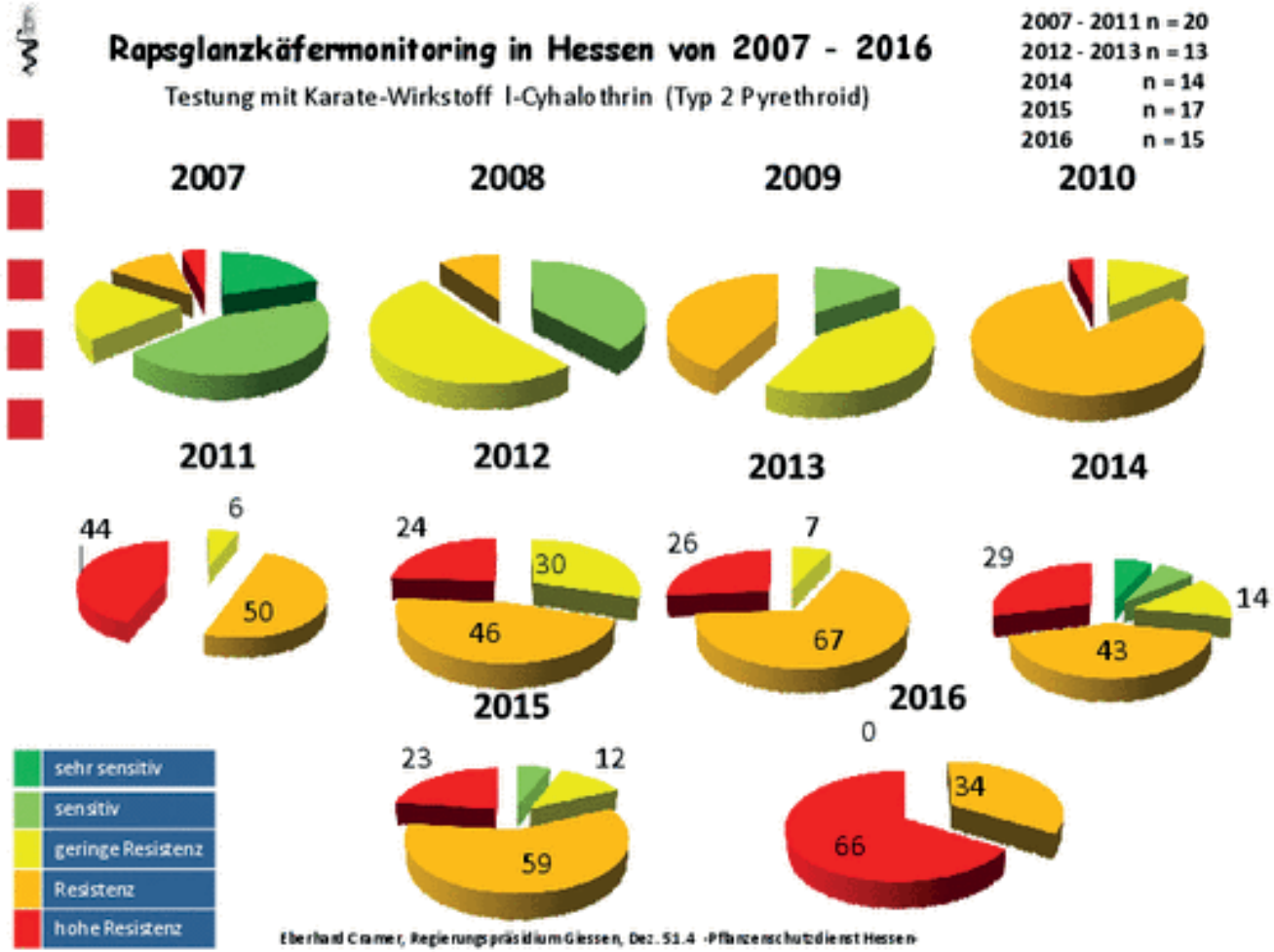
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fraunhofer IME

Dringender Bedarf für neue Optionen zur Kontrolle von Schadinsekten

- Zunehmende Insektizidresistenzen
- Negativer Einfluss auf die Biodiversität
- Bienen- und Vogelsterben

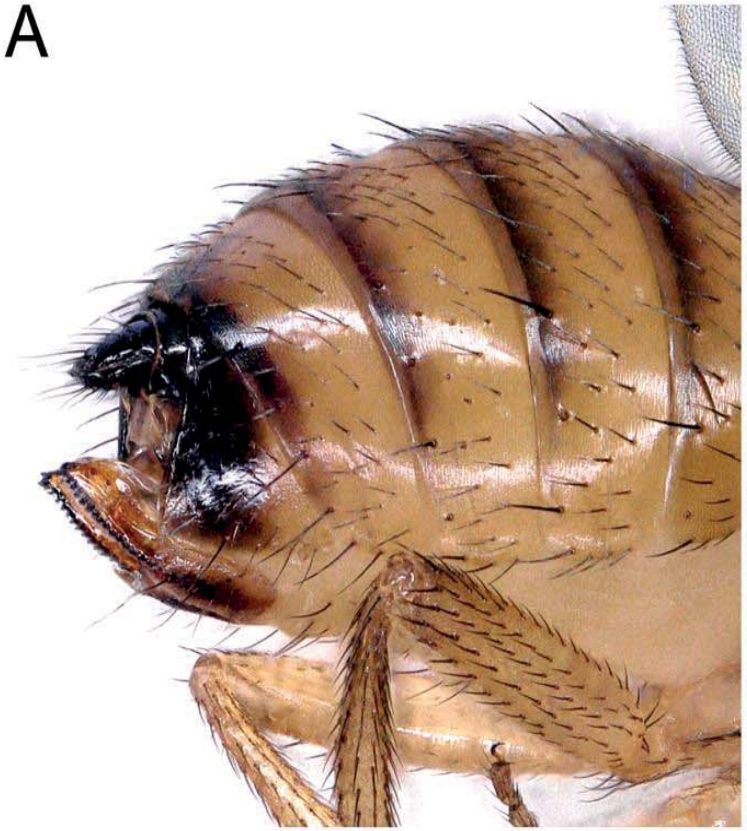




Dringender Bedarf für neue Optionen zur Kontrolle von Schadinsekten

- **Invasive Schadinsekten werden zunehmen**
- **Beispiel: Die Kirschessigfliege *Drosophila suzukii***

A



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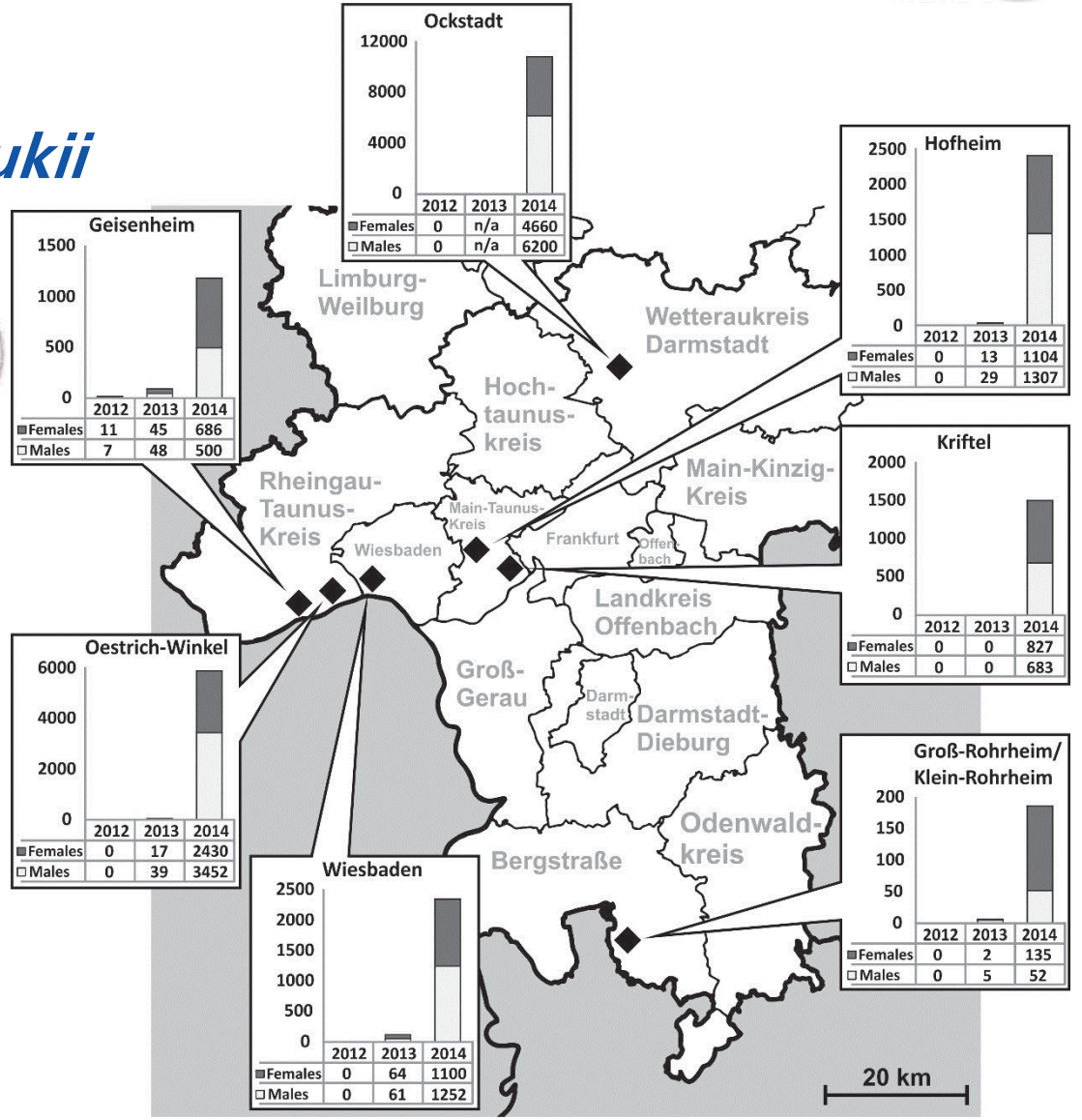


JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

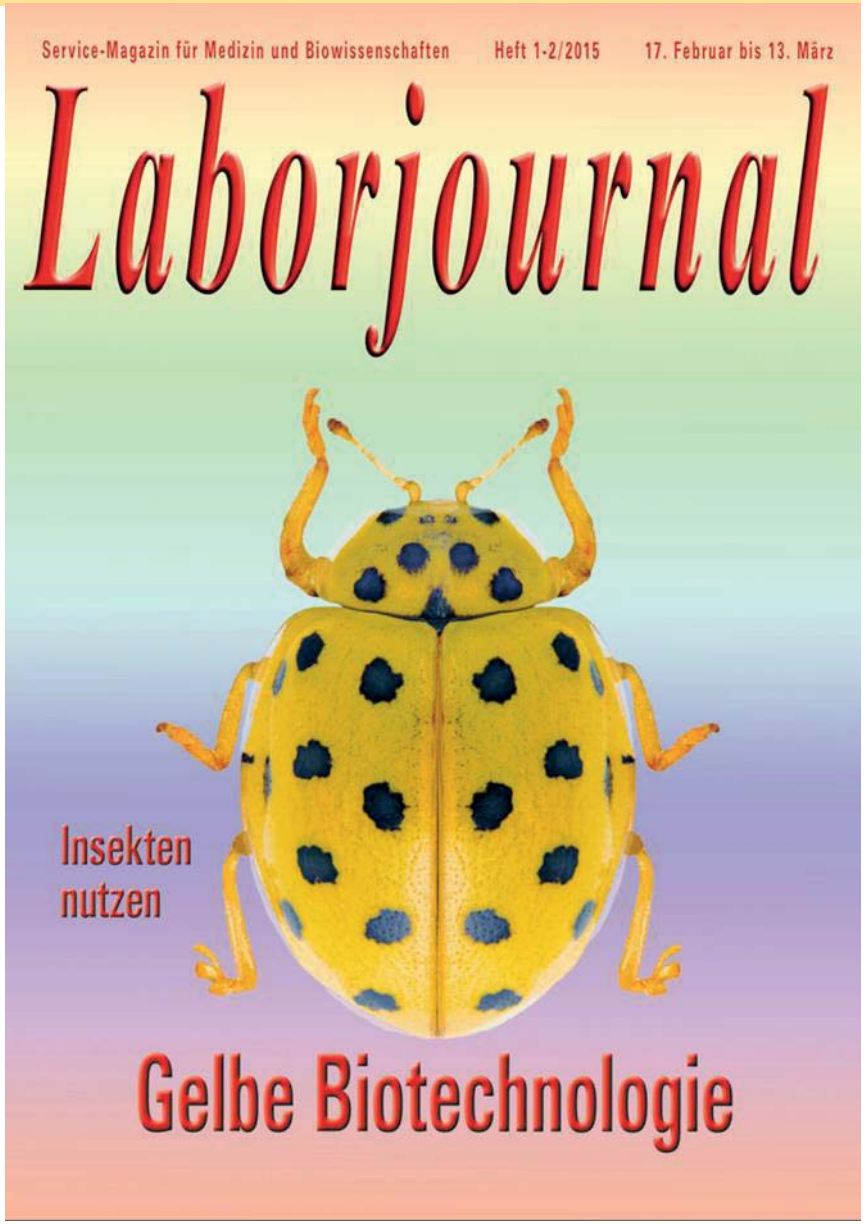
Schetelig et al. 2017: Journal of Applied Entomology, in press

Fraunhofer IME

Insektenbiotechnologie

- **Wir definieren: Insektenbiotechnologie (Gelbe Biotechnologie) ist die Entwicklung und Anwendung biotechnologischer Methoden, um Insekten bzw. von diesen stammende Moleküle, Zellen, Organe oder assoziierten Mikroorganismen als Produkte oder Dienstleistungen nutzbar zu machen.**

- **Insektenbiotechnologie beinhaltet auch die Entwicklung biotechnologischer Methoden zur Kontrolle von Schad- und Vektorinsekten**



Gründung des weltweit ersten Instituts für Insektenbiotechnologie an der JLU Gießen in 2015

ZIB LOEWE Zentrum für Insektenbiotechnologie & Bioressourcen

LOEWE
Exzellente Forschung für Hessens Zukunft

- **Fünf Professuren, darunter die erste für Insektenbiotechnologie im Pflanzenschutz**

Ziele:

- **Deutschlandweit führende Einrichtung für die Entwicklung biotechnologischer Methoden zur nachhaltigen Bekämpfung von Schad- und Vektorinsekten**
- **Aufbau des ersten internationalen Masterstudiengangs für „Insect Biotechnology“**

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Aufbau des Fraunhofer Instituts für Bioressourcen in Gießen

- Die Fraunhofer Gesellschaft ist die größte und erfolgreichste Forschungsorganisation Europas in den angewandten Wissenschaften
- Von den 70 FhG-Instituten sind 5 in den Lebenswissenschaften angesiedelt
- Das im Aufbau befindliche Fraunhofer Institut in Gießen ist das erste, das sich der Entwicklung von innovativen, biotechnologischen Methoden zur Kontrolle von Schad- und Vektorinsekten widmet.
- Translationale Forschung, die sich an der Wertschöpfungskette orientiert.
- Entwicklung von Produkten und Dienstleistungen mit Industriepartnern

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fraunhofer IME

LOEWE

Exzellente Forschung für Hessens Zukunft

Aufbau des Fraunhofer Instituts für Bioressourcen in Gießen

Hessisches Landesamt für Naturschutz, Umwelt und Geologie
Fachzentrum Klimawandel Hessen

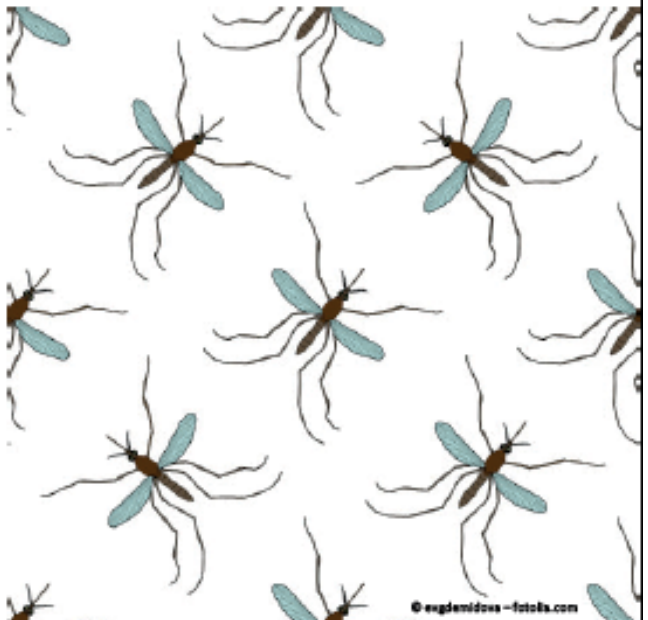
HESSEN

Fachtagung

Stechmücken – Monitoring und Forschung bundesweit und in Hessen

27. Juni 2016

Wiesbaden
Landeshaus, Plenarsaal



JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fraunhofer IME

Forschung entlang der Wertschöpfungskette

Bioressourcen → **Produkte**

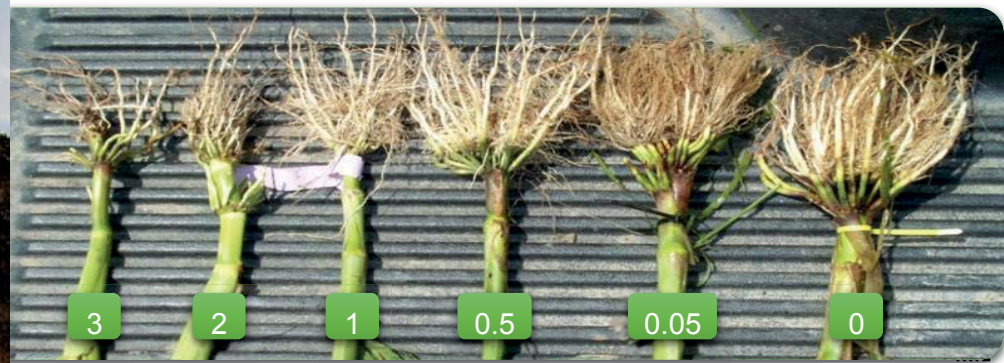
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fraunhofer IME

THM TECHNISCHE HOCHSCHULE MITTELHESSEN

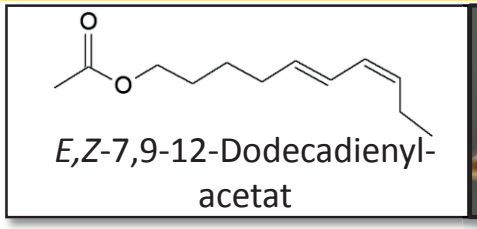
SANOFI

DOW Dow AgroSciences

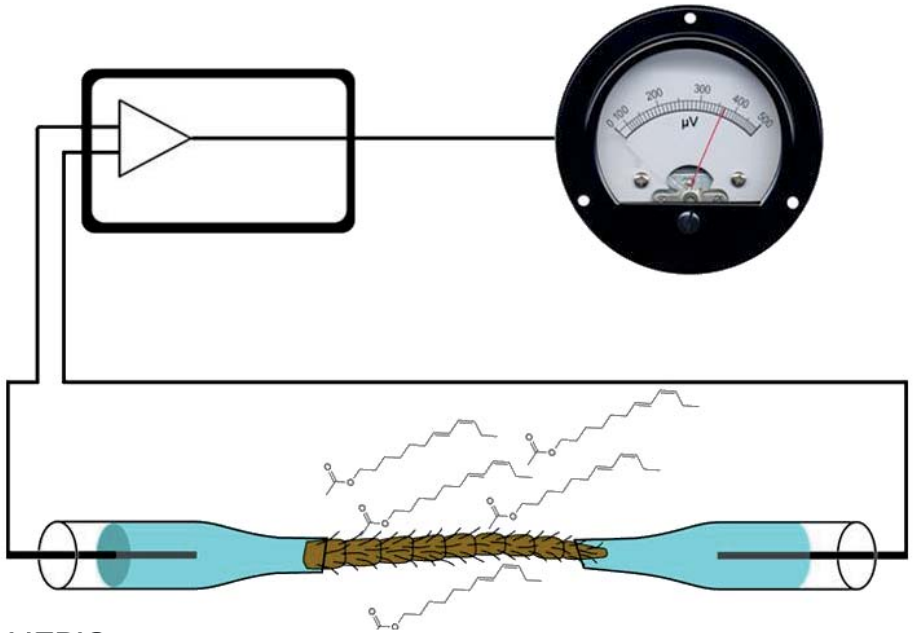


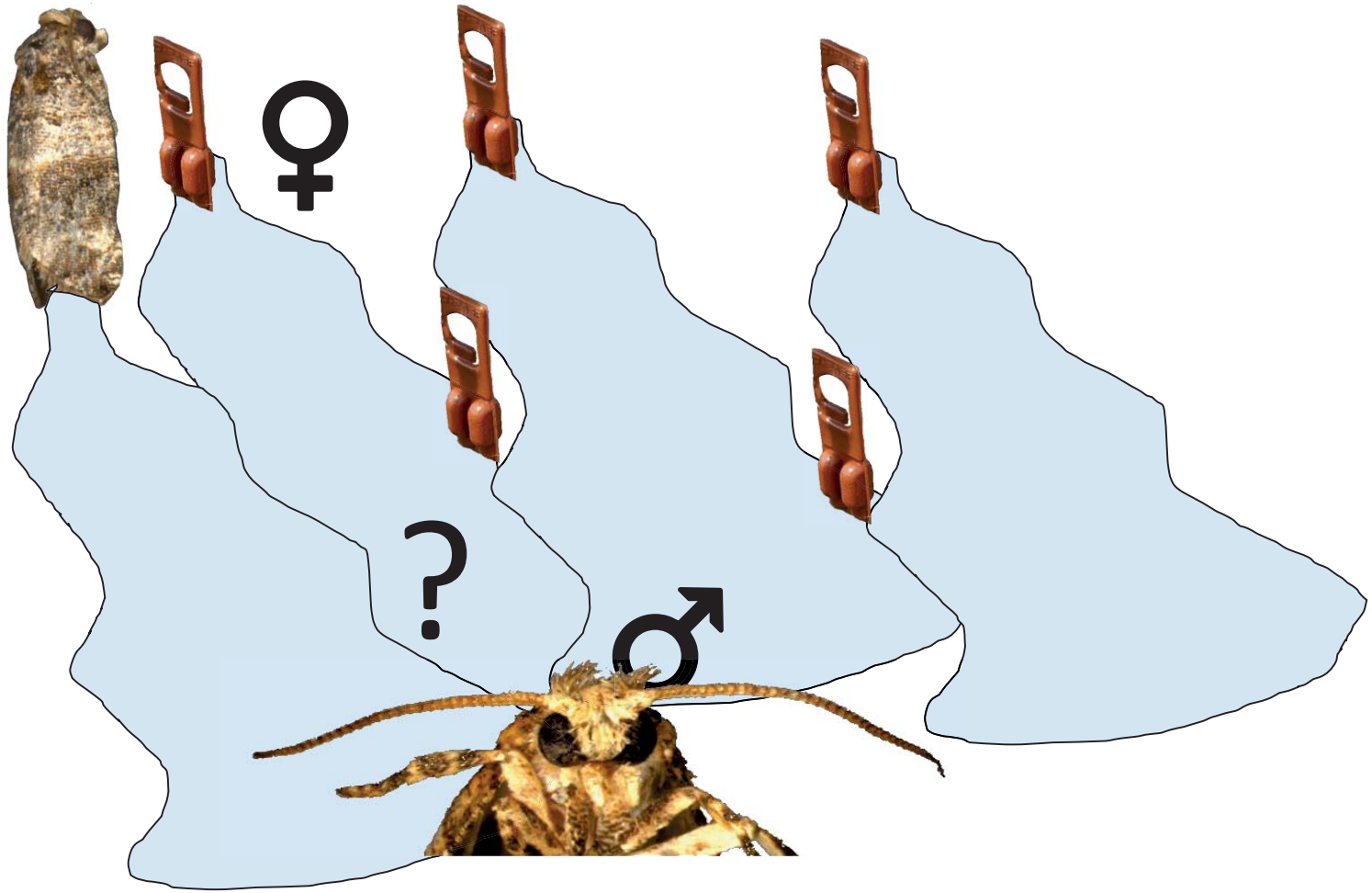
Forschungsschwerpunkt: Chemische Ökologie

- **Optimierung der „Verwirrtechnik“ im Pflanzenschutz**
- **Erweiterung der Anwendungsbereiche**
- **Entwicklung von in situ-Methoden zur Detektion von Pheromonen**



E,Z-7,9-12-Dodecadienyl-acetat





JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Schott et al. 2013: Advances Biochemical Engineering & Biotechnology

Fraunhofer IME

Forschungsschwerpunkt: Chemische Ökologie

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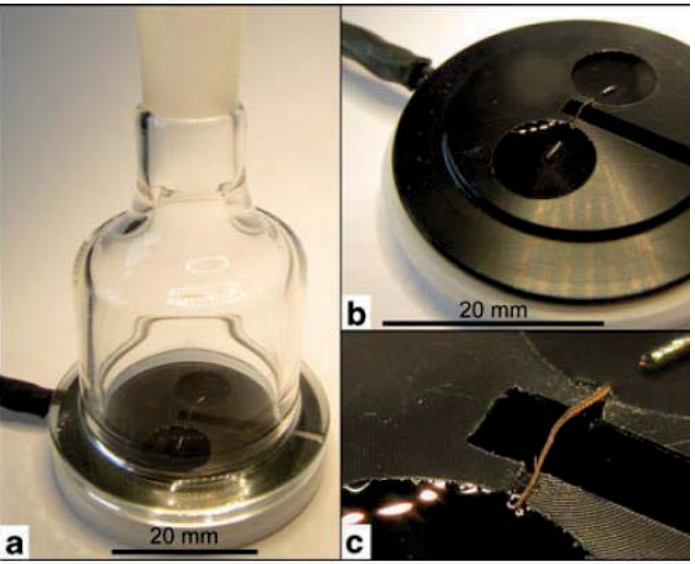
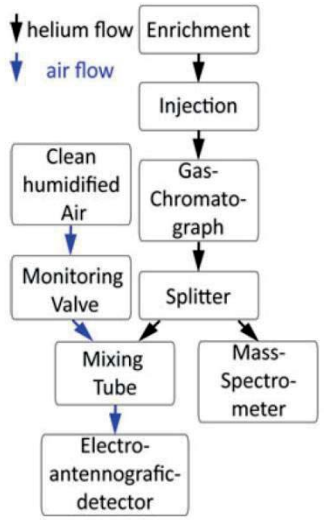
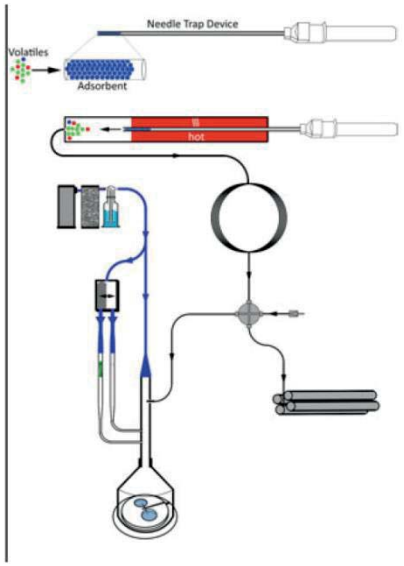
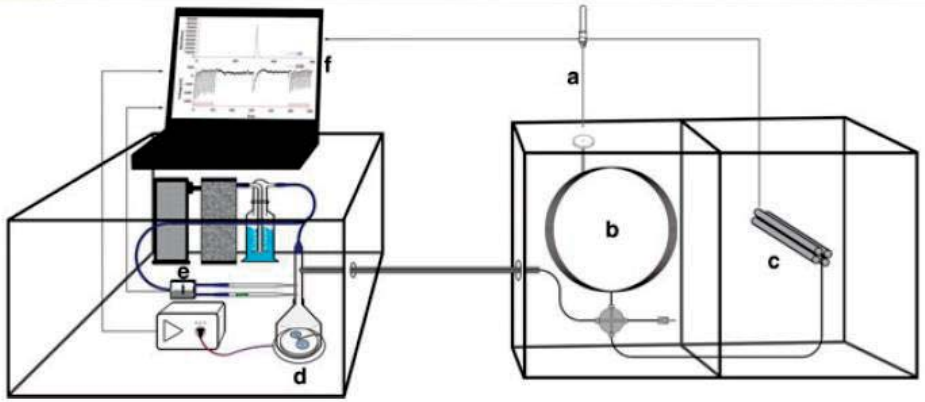






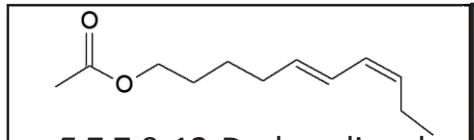


Schott et al. 2013: Analytical and Bioanalytical Chemistry

Forschungsschwerpunkte: Chemische Ökologie

- **Insektenantennen als**

  Biosensoren für in situ Studien



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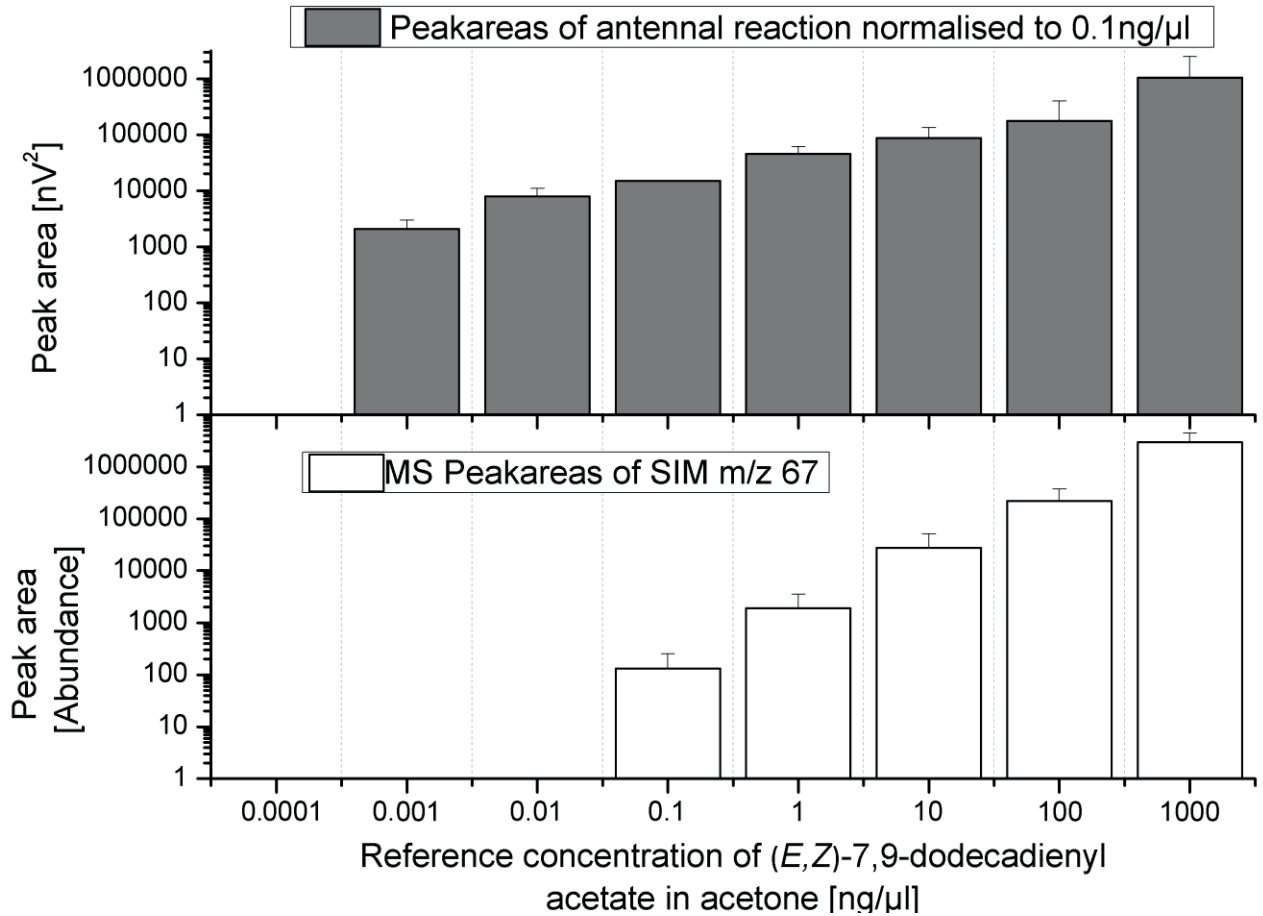


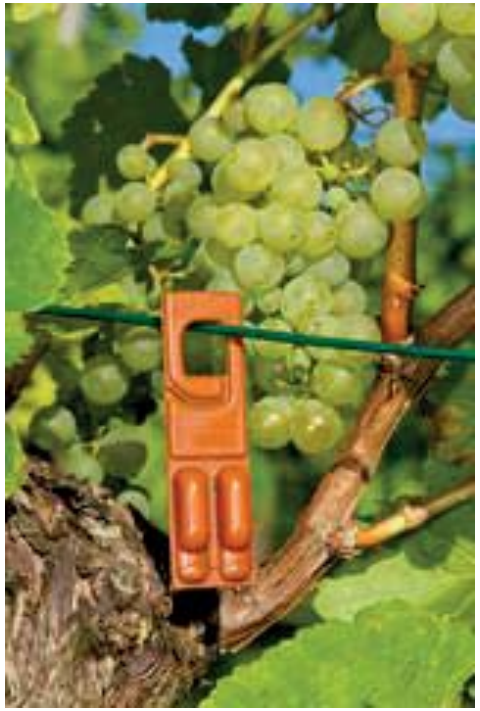
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

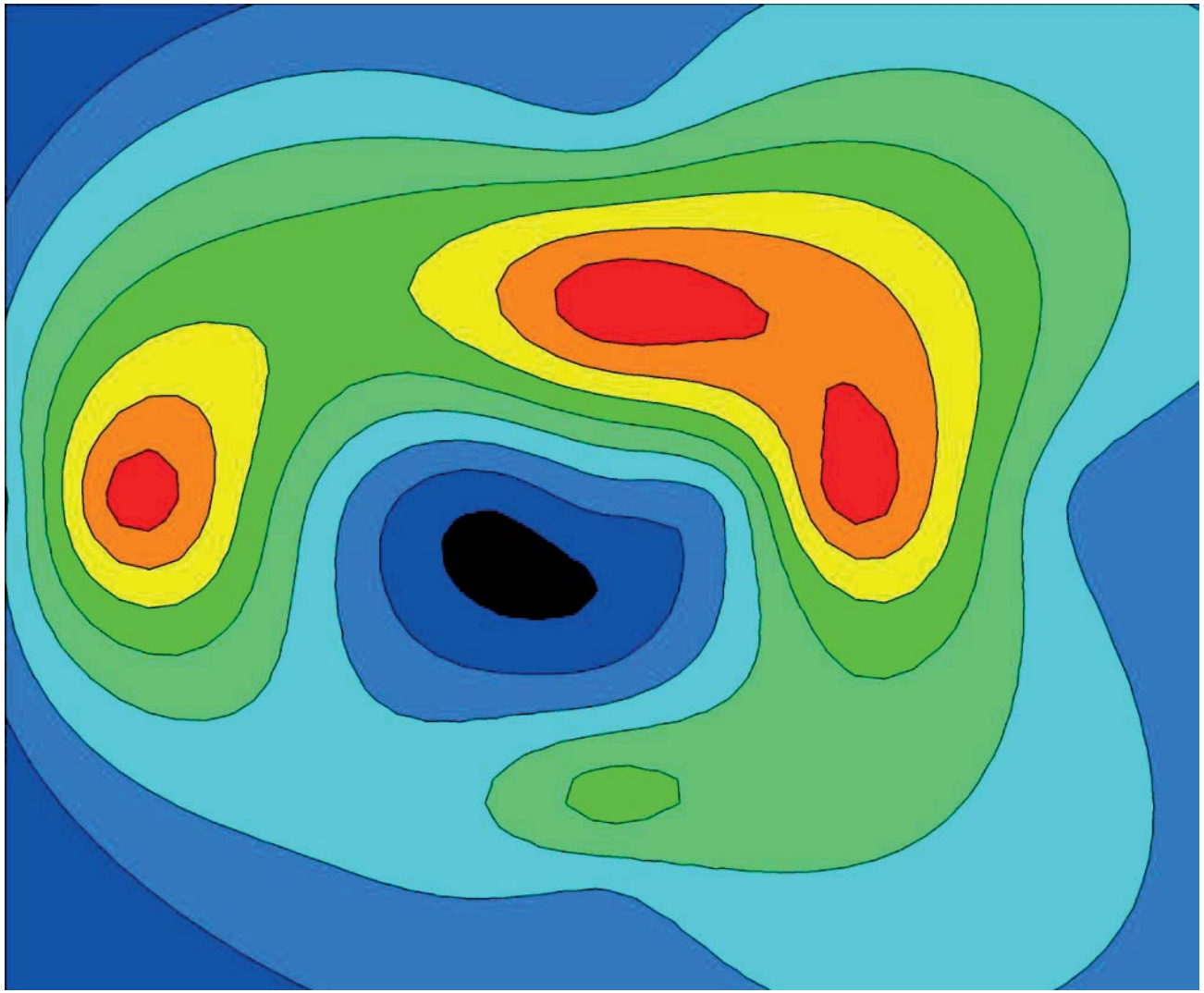
Schott et al. 2013: Analytical and Bioanalytical Chemistry

Fraunhofer IME

Forschungsschwerpunkt: Chemische Ökologie

- Modellierung der Ausbreitung von Pheromonen in Abhängigkeit von der Topografie
- Optimierung der Ausbringung von Dispensern





JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Schott et al. 2013: Analytical and Bioanalytical Chemistry

Fraunhofer IME

Forschungsschwerpunkt: Sterile-Insekten-Technik (SIT)

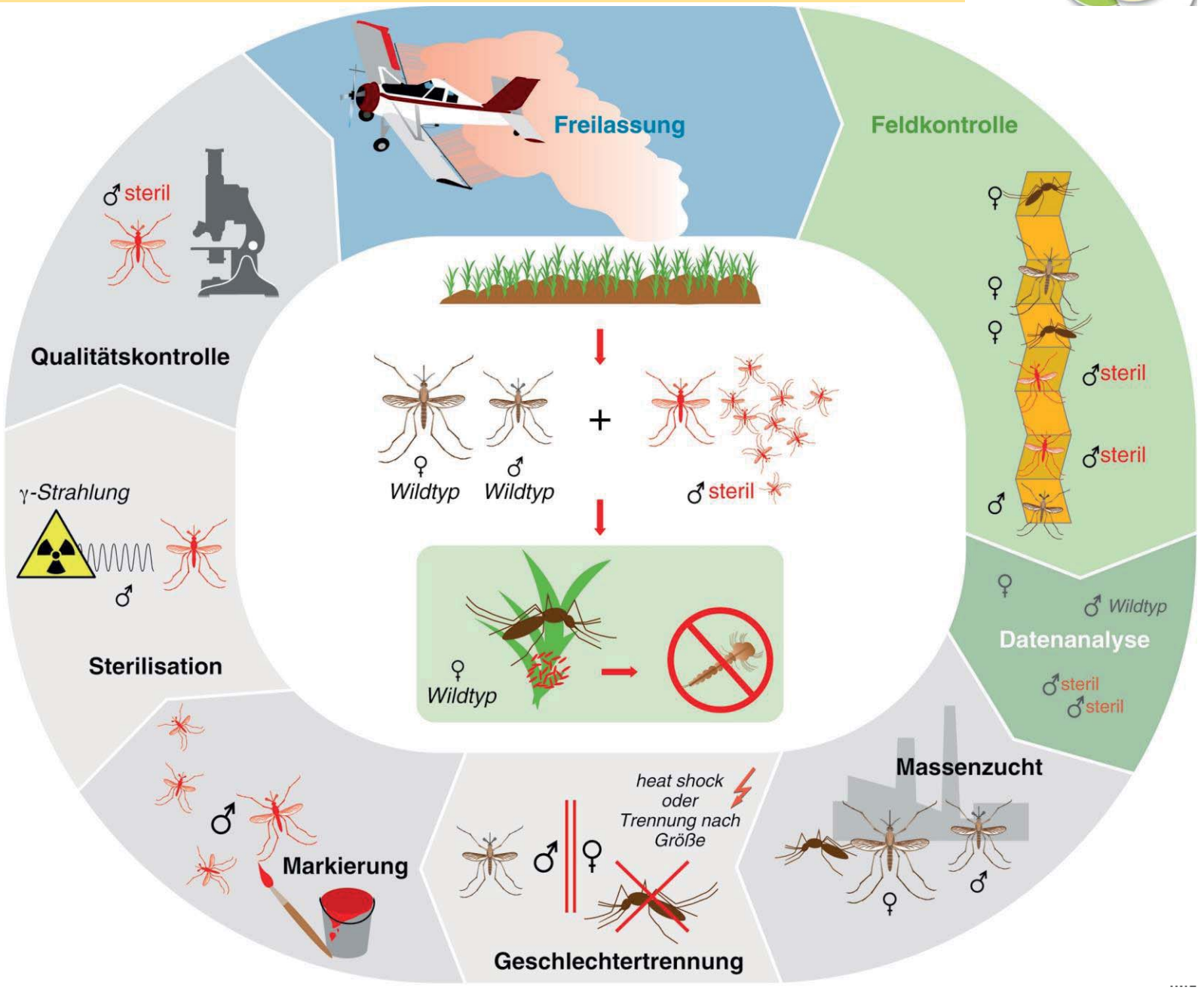
Prof. Dr. Marc Schetelig
Professur für Insektenbiotechnologie im Pflanzenschutz, JLU

Fraunhofer Attract-Nachwuchsgruppe

Emmy-Noether Nachwuchsgruppe

LOEWE HESSEN

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN



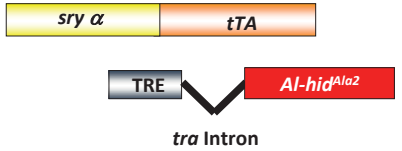
Forschungsschwerpunkt: Sterile-Insekten-Technik (SIT)

Prof. Dr. Marc Schetelig
Professur für Insektenbiotechnologie im Pflanzenschutz, JLU

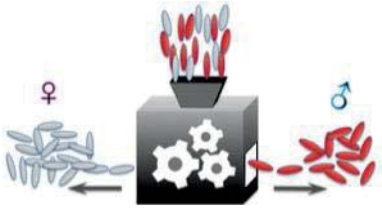
- **Lethalgene**
- **Sexing-Systeme**
- **Marker**

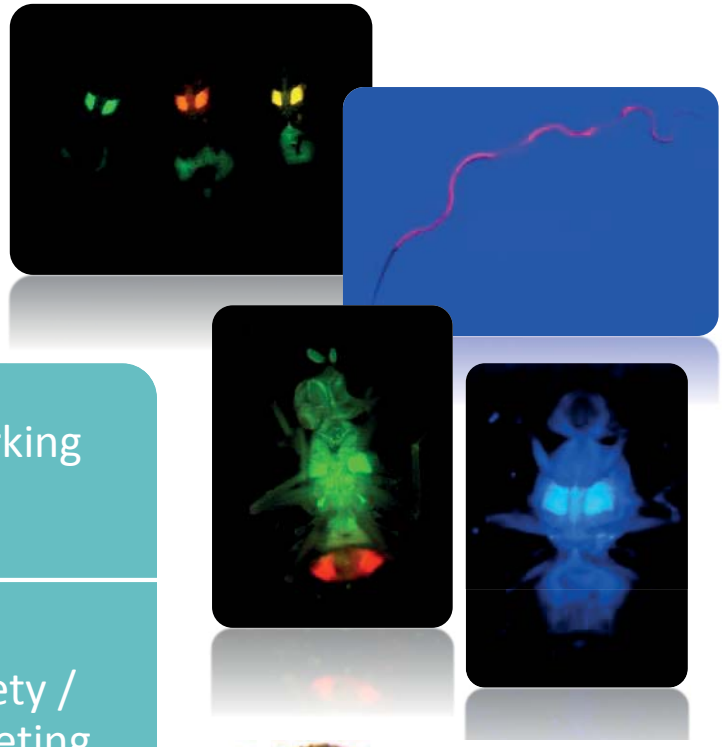
Sex reversion

Female-specific lethality



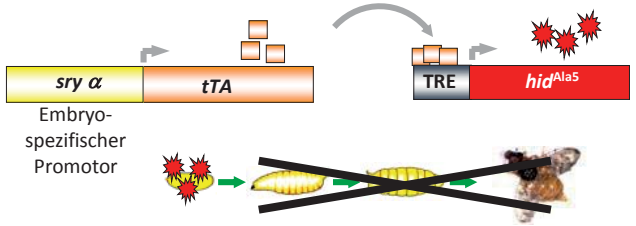
Sex sorting





Sexing | Marking | SIT | Sterilization | Safety / Targeting

Unisex lethality

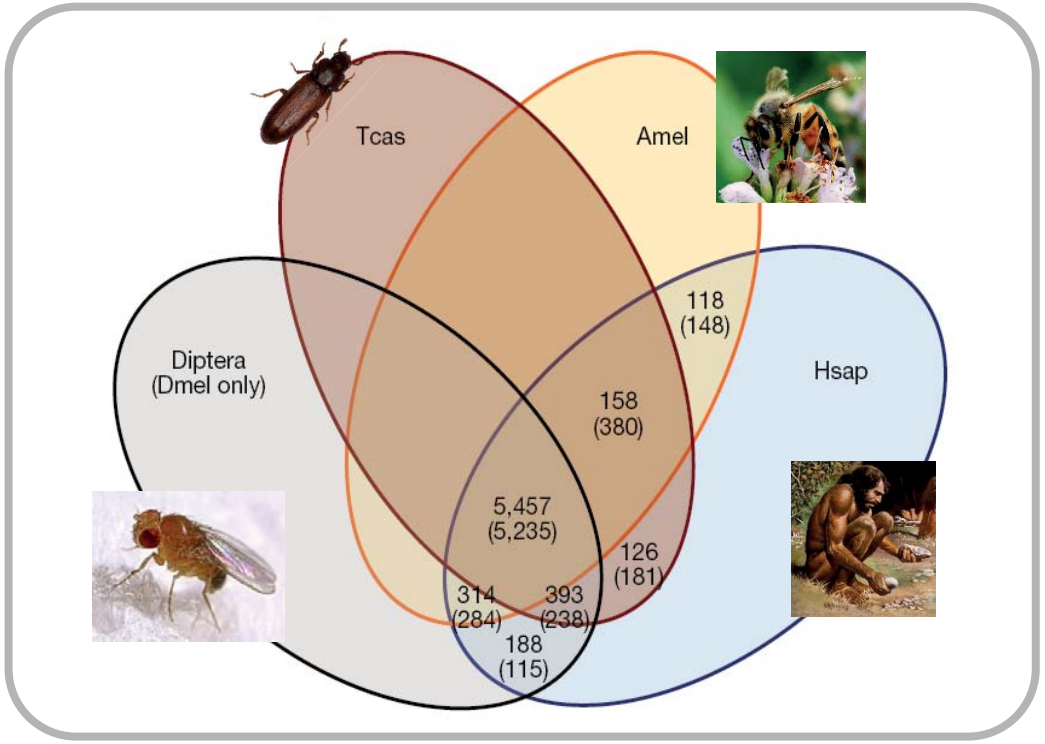


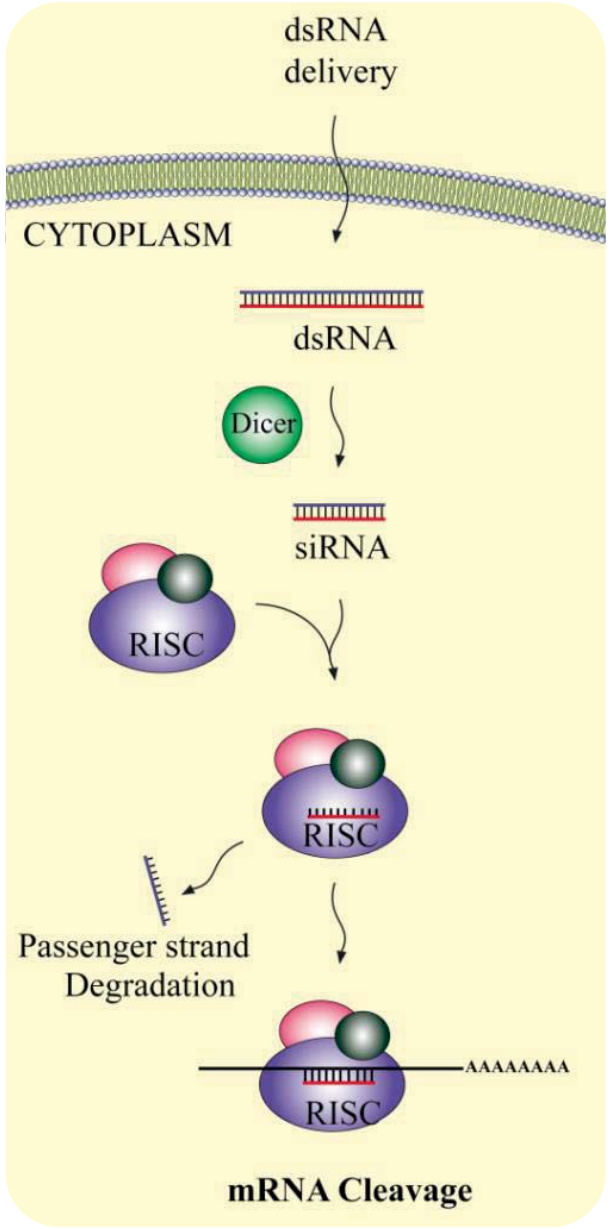
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz

- Natürlicher Mechanismus in eukaryotischen Zellen
- Ausgelöst durch dsRNA
- Verhindert die Translation in ein Protein
- Vorteil: dsRNA kann artspezifisch designt werden
- Keine Gefahr für Nichtzielorganismen

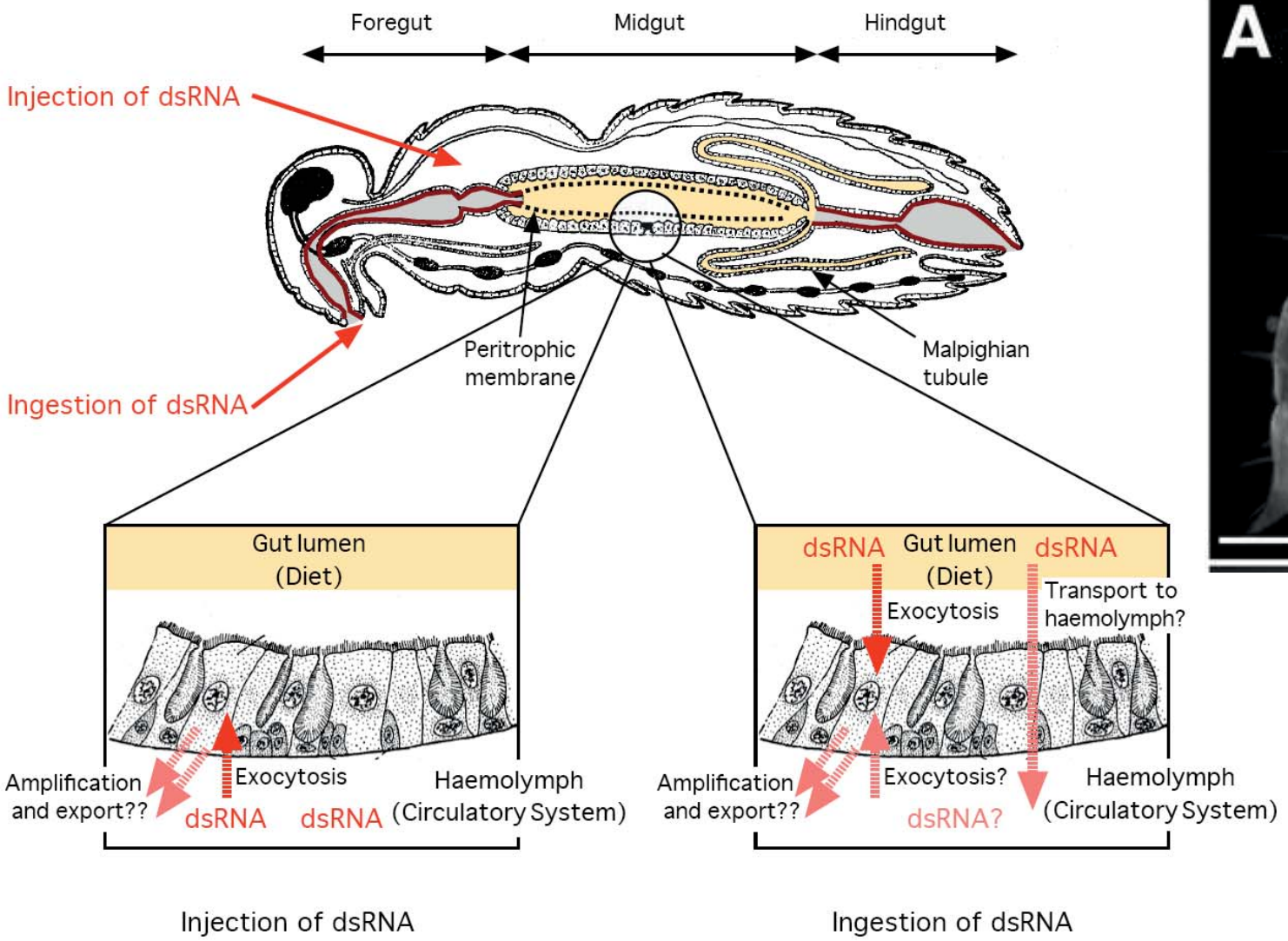
Craig Mello and Andrew Fire (re.)
Medizin-Nobelpreis 2006.

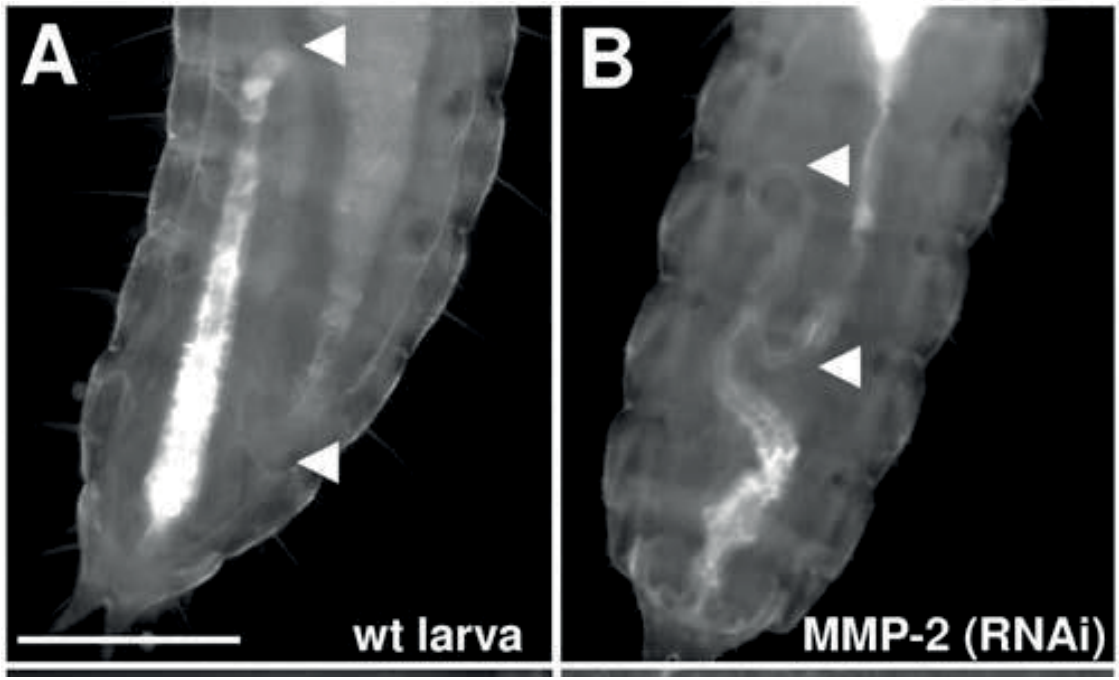




Knorr, Bingsohn, Kanost, Vilcinskas 2013: Advances Biochemical Engineering and Biochemistry 136, 163-178

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz





Knorr et al. 2009: PLoS One 4(3):e7451

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

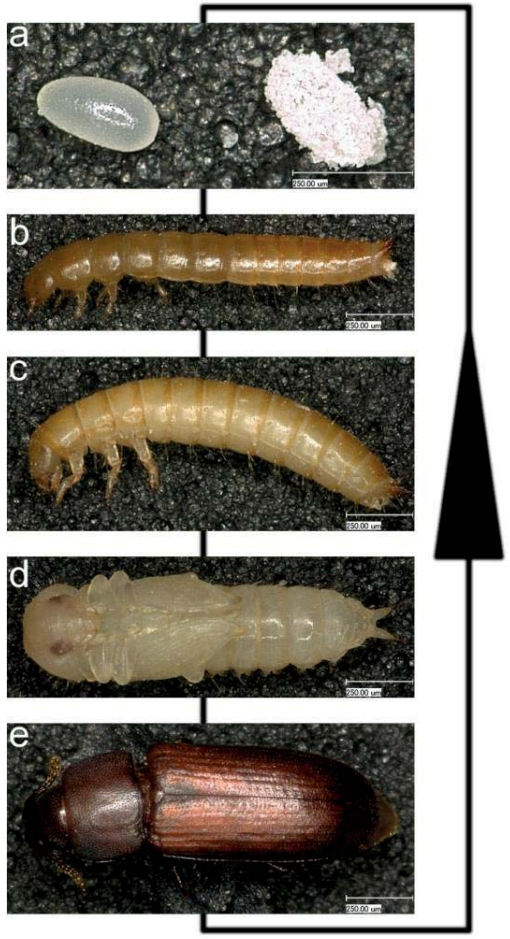
Fraunhofer IME

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz

Rotbrauner Reismehlkäfer
Tribolium castaneum

Vorteile:

- Kurze Generationszeit,
- hohe Fortpflanzungsrate
- einfache Haltung
- Sequenziertes Genom
- Zugänglich zu systemischer und parentaler RNA-Interferenz (RNAi)



Vol 452|24 April 2008|doi:10.1038/nature06784 nature

ARTICLES

The genome of the model beetle and pest *Tribolium castaneum*

Tribolium Genome Sequencing Consortium*

Tribolium castaneum is a member of the most species-rich eukaryotic order, a powerful model organism for the study of generalized insect development, and an important pest of stored agricultural products. We describe its genome sequence here. This omnivorous beetle has evolved the ability to interact with a diverse chemical environment, as shown by large expansions in odorant and gustatory receptors, as well as P450 and other detoxification enzymes. Development in *Tribolium* is more representative of other insects than is *Drosophila*, a fact reflected in gene content and function. For example, *Tribolium* has retained more ancestral genes involved in cell–cell communication than *Drosophila*, some being expressed in the growth zone crucial for axial elongation in short-germ development. Systemic RNA interference in *T. castaneum* functions differently from that in *Caenorhabditis elegans*, but nevertheless offers similar power for the elucidation of gene function and identification of targets for selec

OPEN ACCESS Freely available online PLoS BIOLOGY

Genome Sequence of the Pea Aphid *Acyrthosiphon pisum*

The International Aphid Genomics Consortium¶*

Abstract

Aphids are important agricultural pests and also biological models for studies of insect-plant interactions, symbiosis, virus vectoring, and the developmental causes of extreme phenotypic plasticity. Here we present the 464 Mb draft genome assembly of the pea aphid *Acyrthosiphon pisum*. This first published whole genome sequence of a basal hemimetabolous insect provides an outgroup to the multiple published genomes of holometabolous insects. Pea aphids are host-plant specialists, they can reproduce both sexually and asexually, and they have coevolved with an obligate bacterial symbiont. Here we highlight findings from whole genome analysis that may be related to these unusual biological features. These findings include discovery of extensive gene duplication in more than 2000 gene families as well as loss of evolutionarily conserved genes. Gene family expansions relative to other published genomes include genes involved in chromatin modification, miRNA synthesis, and sugar transport. Gene losses include genes central to the IMD immune pathway, selenoprotein utilization, purine salvage, and the entire urea cycle. The pea aphid genome reveals that only a limited number of genes have been acquired from bacteria; thus the reduced gene count of *Buchnera* does not reflect gene transfer to the host genome. The inventory of metabolic genes in the pea aphid genome suggests that there is extensive metabolite exchange between the aphid and *Buchnera*, including sharing of amino acid biosynthesis between the aphid and *Buchnera*. The pea aphid genome provides a foundation for post-genomic studies of fundamental biological questions and applied agricultural problems.

Citation: The International Aphid Genomics Consortium (2010) Genome Sequence of the Pea Aphid *Acyrthosiphon pisum*. PLoS Biol 8(2): e1000313. doi:10.1371/journal.pbio.1000313

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz

Rotbrauner Reismehlkäfer
Tribolium castaneum

Vorteile:

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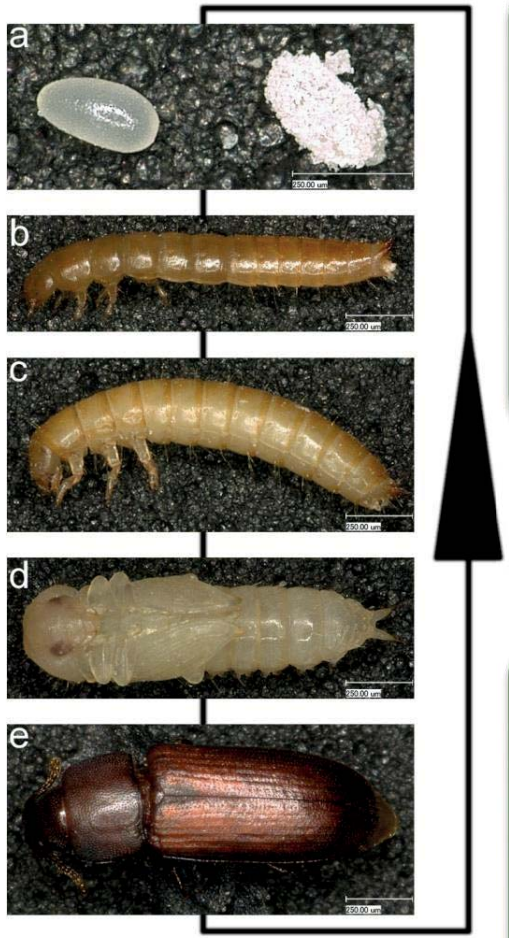
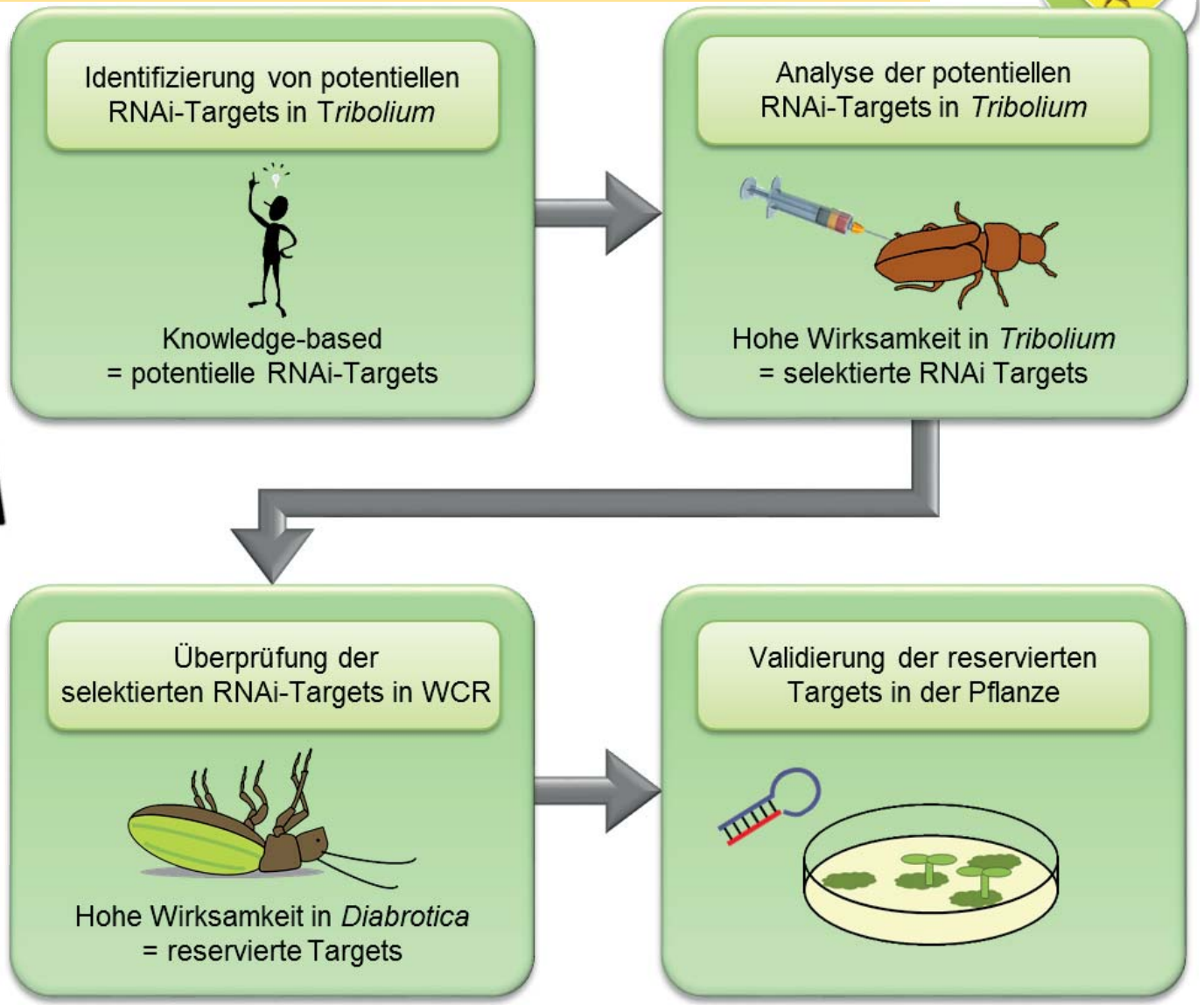
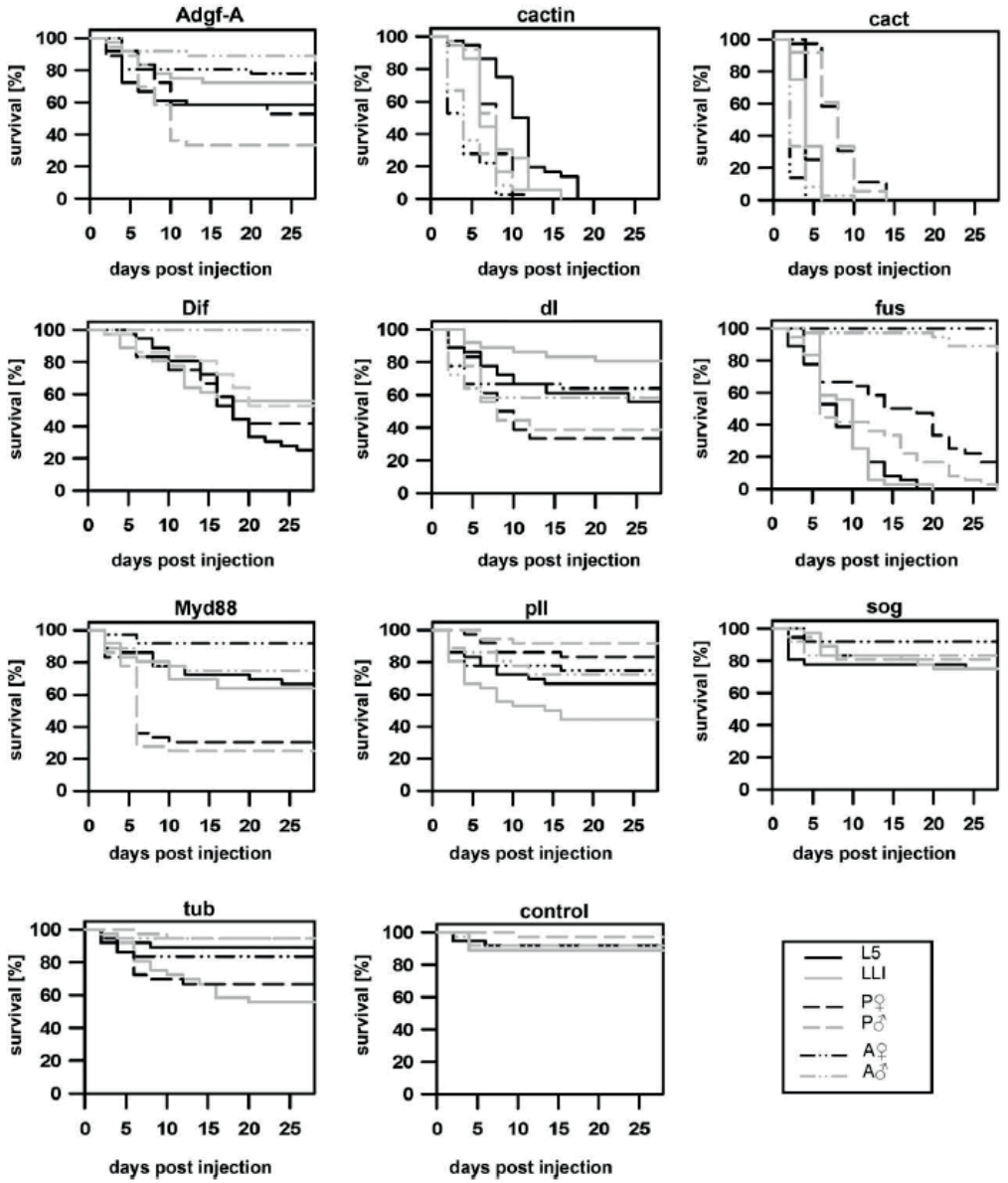
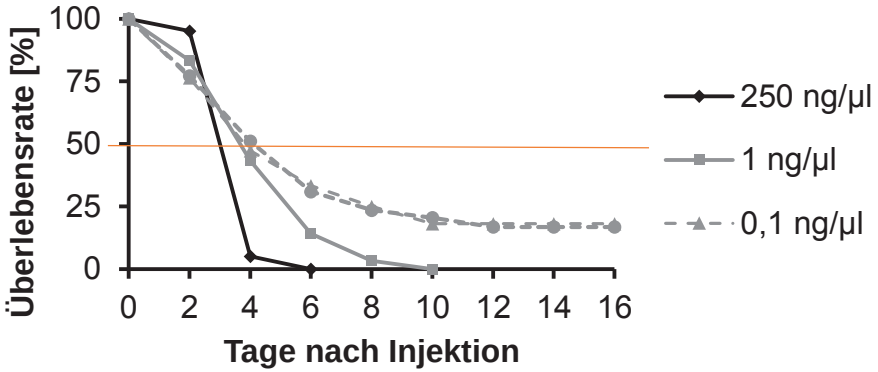


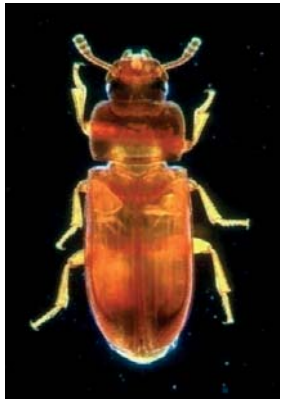


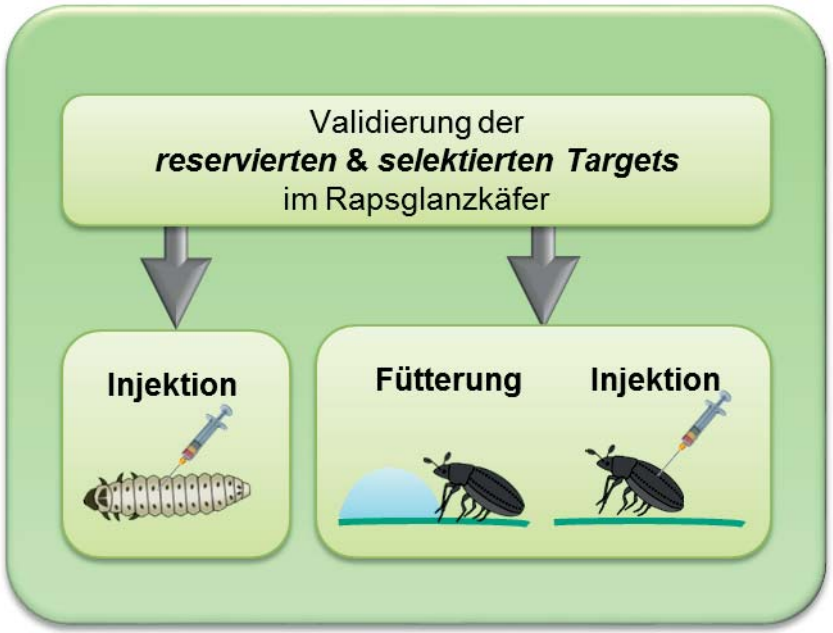
Knorr, Bingsohn, Kanost, Vilcinskas 2013: Advances Biochemical Engineering and Biochemistry 136, 163-178

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz



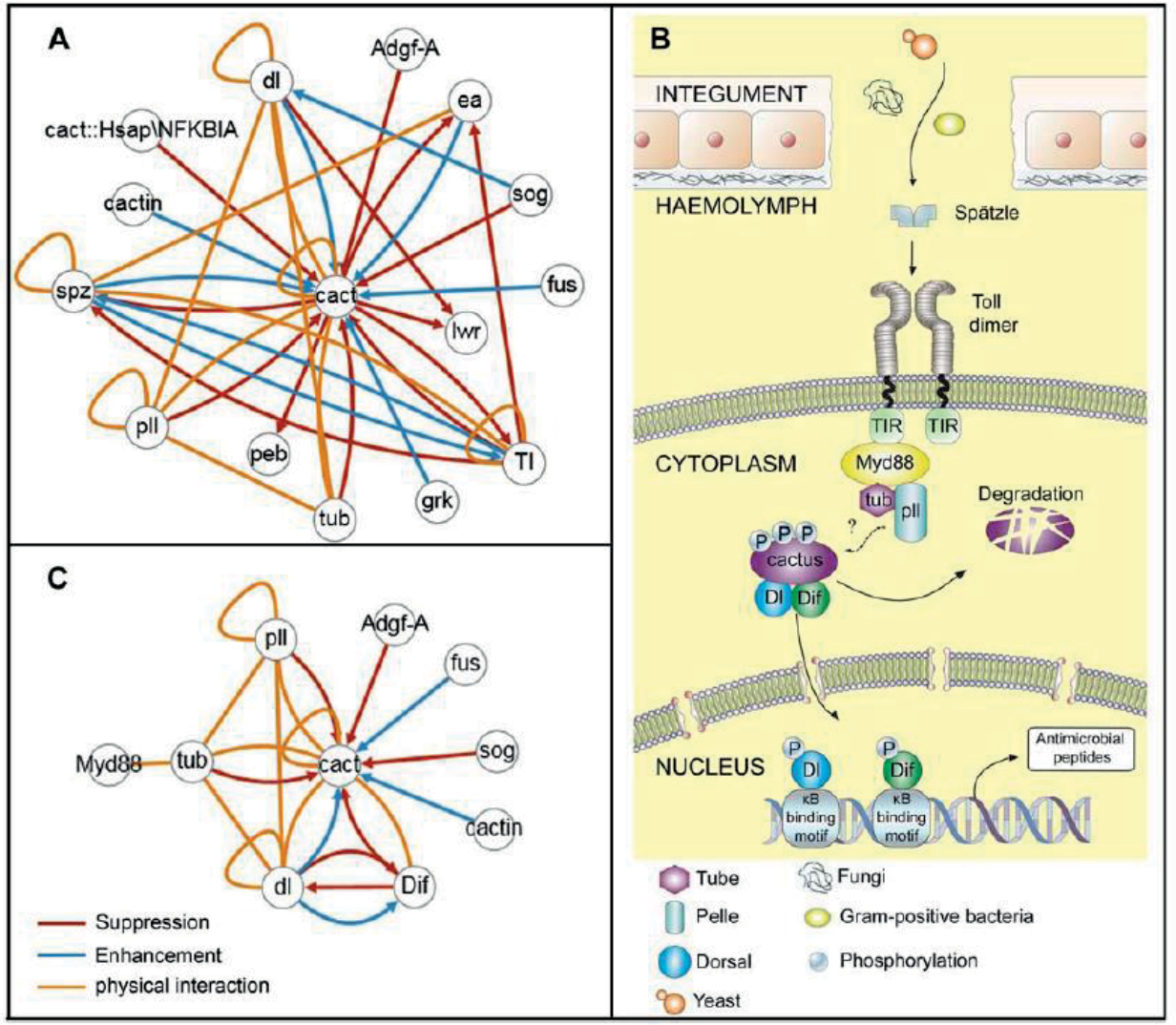






Bingson, Knorr, Narva Vilcinskas 2017: Insect Molecular Biology (2017) 26(1), 92–102

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz



Bingson, Knorr, Narva Vilcinskas 2017: Insect Molecular Biology (2017) 26(1), 92–102

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz

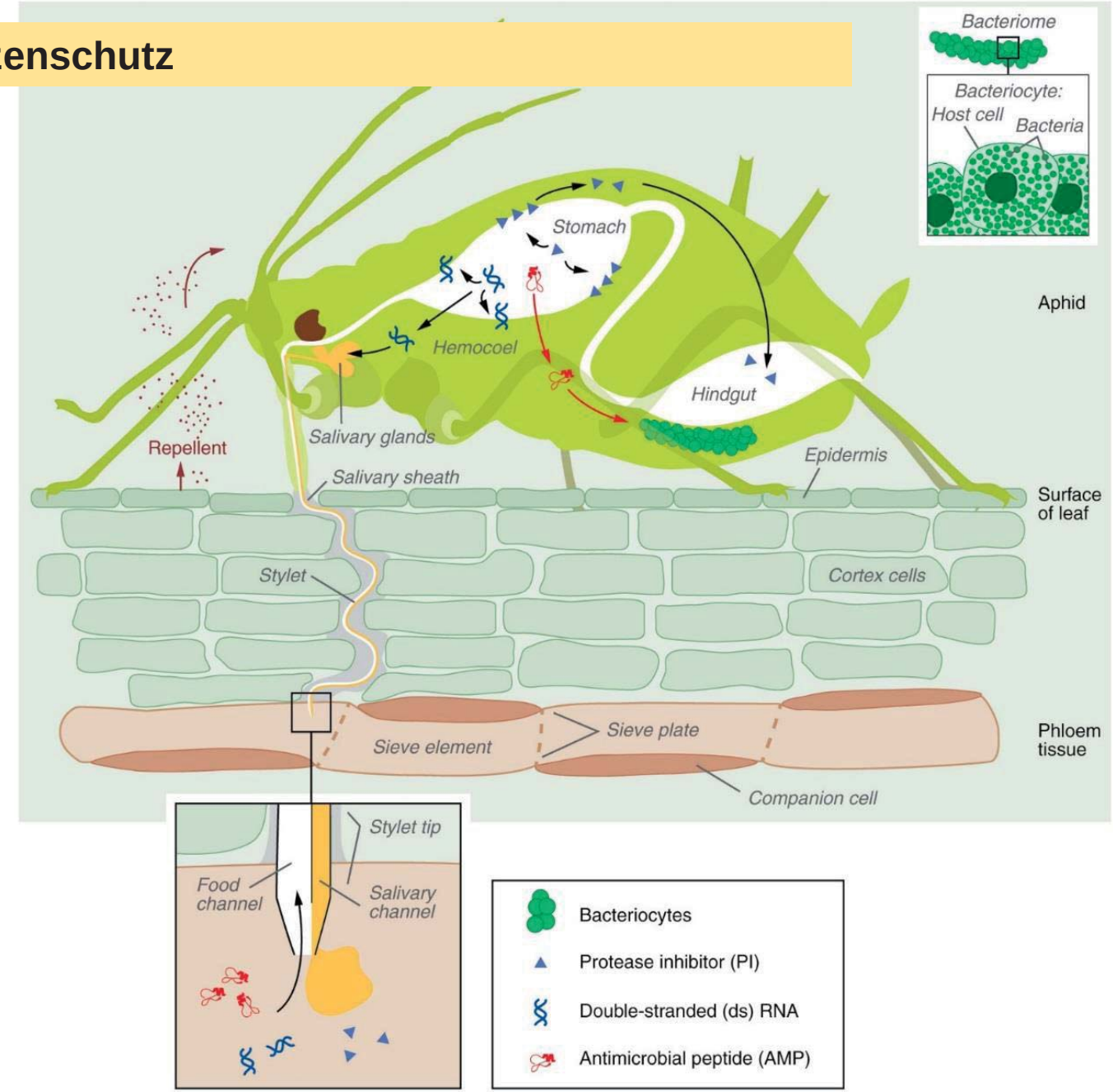
Forschungsbedarf

- Sicherheit für Nichtzielorganismen
- Produktsicherheit
- Sachgerechte Anwendung
- Formulierung, bei sprayable dsRNAs

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz

	Schädling	Model aphid
	Getreideblattlaus *Sitobion avenae*	Erbsen-Blattlaus *Acyrthosiphon pisum*
➢ Genom	nein	ja
➢ Transcriptomes	ja	ja
➢ Rearing	schwierig	leicht

Forschungsschwerpunkt: RNA-Interferenz im Pflanzenschutz



JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Fraunhofer IME

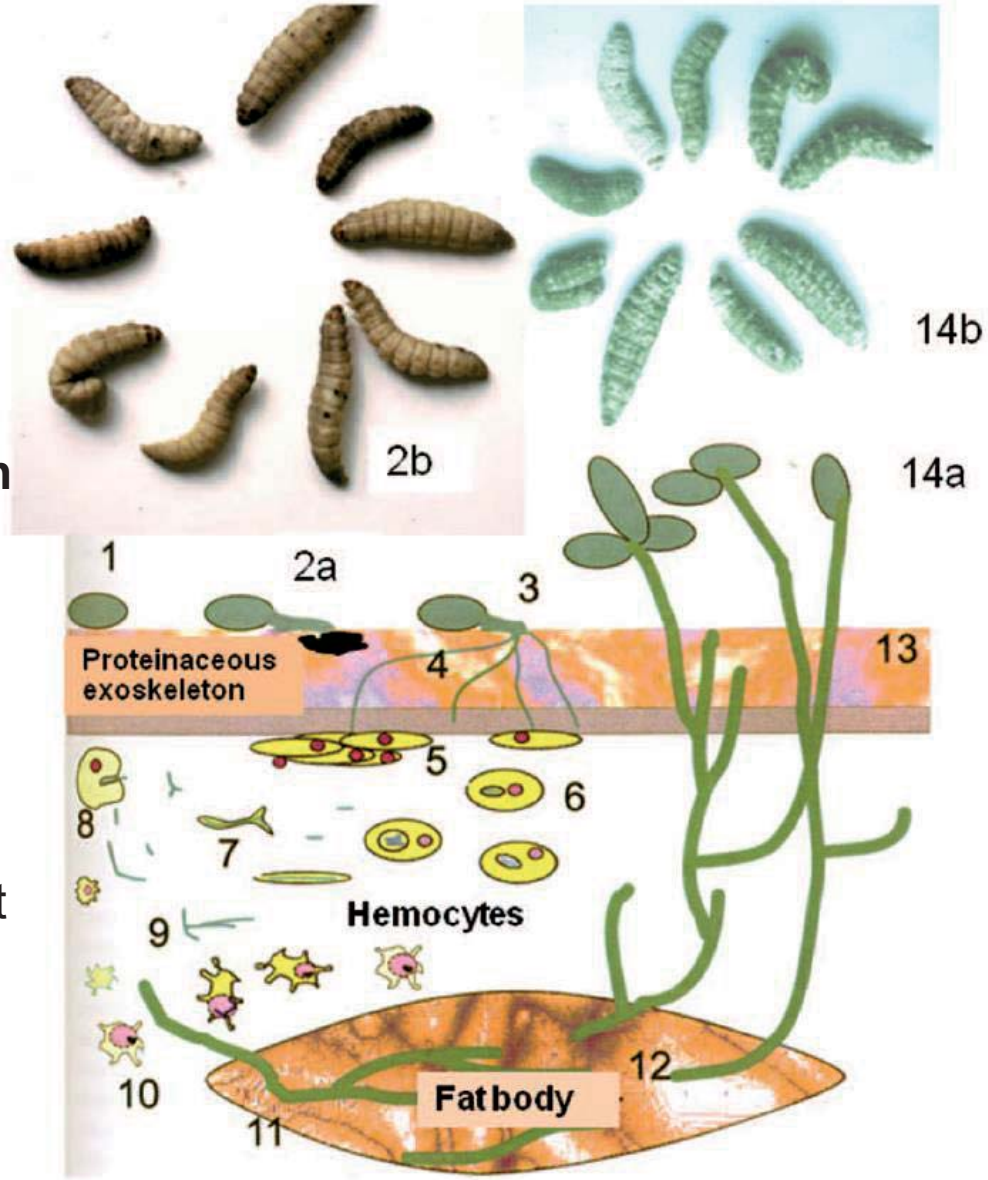
Aufbau einer “Deutschen Stammsammlung für den Pflanzenschutz”

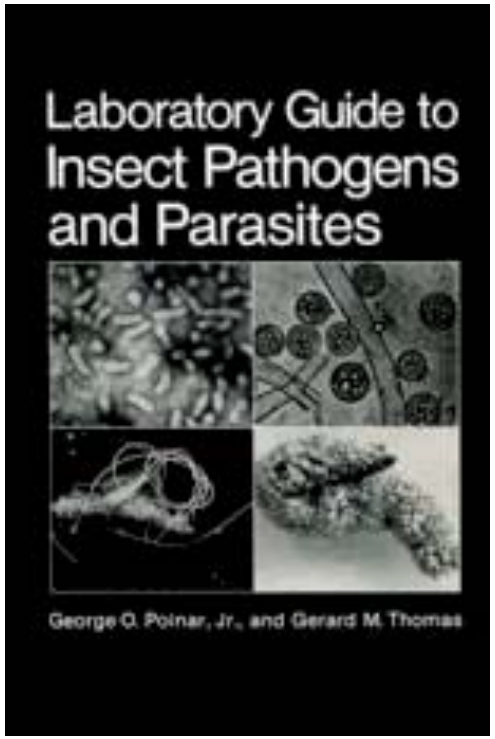
Insektenpathogene

- Viren
- Bakterien (nicht nur B. thuringiensis)
- Pilze
- Nematoden

Was muss die Stammsammlung leisten

- Identifizierung und Archivierung neuer Insektenpathogene
- Erforschung des Anwendungs- und Risikopotenzials
- Entwicklung von geeigneten Verfahrung zur Massenherstellung
- ..und zur Sicherung der Produktqualität





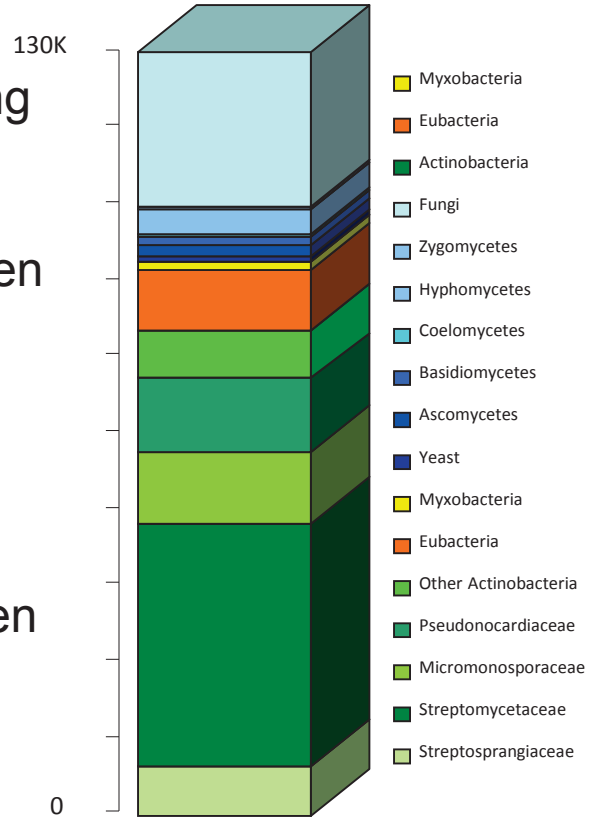
Aufbau einer “Deutschen Stammsammlung für den Pflanzenschutz”

Übertragung der größten industriellen Stammsammlung der Welt von Sanofi an das Fraunhofer IME

Umfangreiche Laborinfrastruktur kann für Erweiterungen genutzt werden

Ziele:

- Stammsammlung mit insektenpathogene Viren, Bakterien, Pilze und Nematoden für den biologischen Pflanzenschutz
- Symbiontische Mikroorganismen
- Mikroben für die Biokonversion
- Genomische Charakterisierung
- Erfassung der sekundären Metaboliten



Im Industriepark Höchst lagert Sanofi eine der weltweit größten Stammsammlungen der Industrie

Die Stammsammlung von Sanofi besteht aus über 130.000 Bakterien-, Pilz- und Einzellerstämmen

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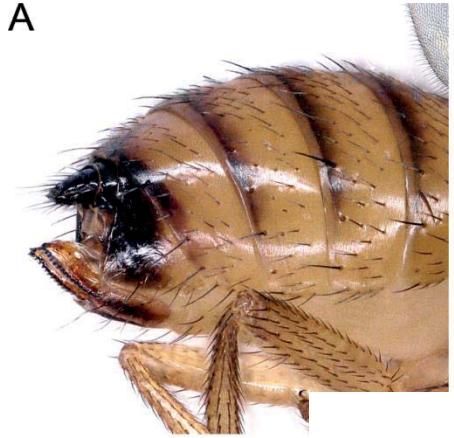
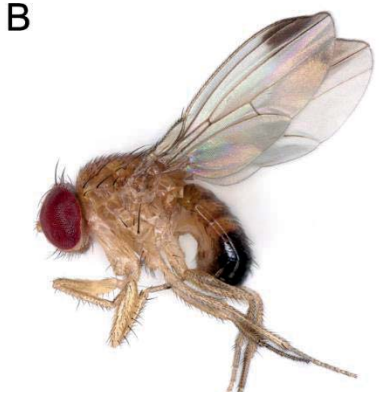
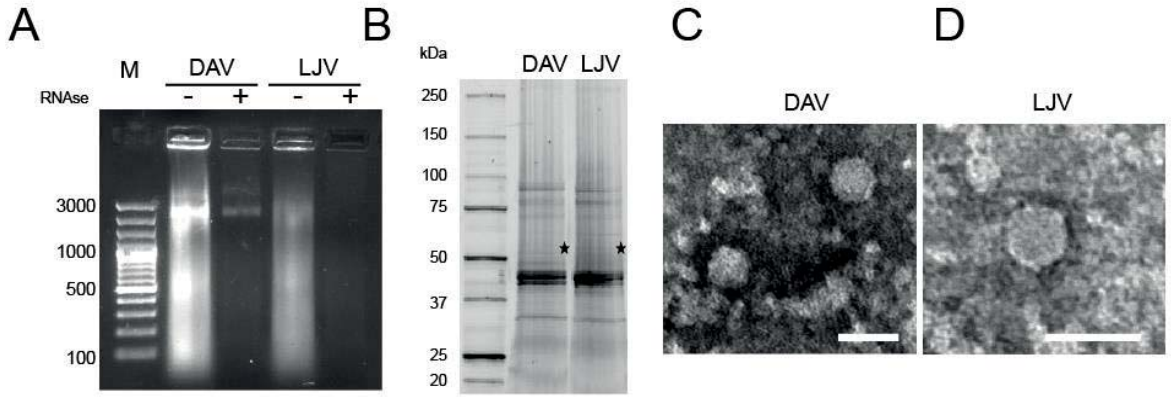
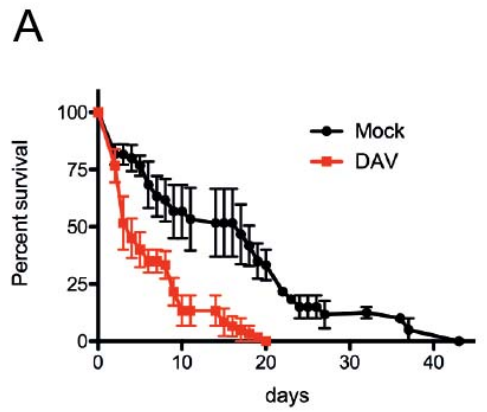
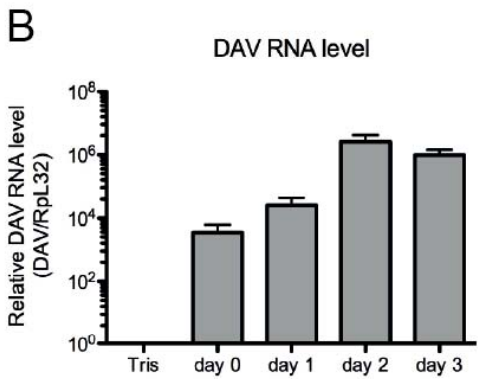
Beispiel neue Viren gegen *Drosophila suzukii*

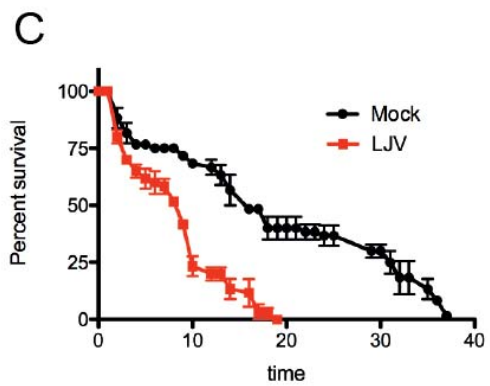


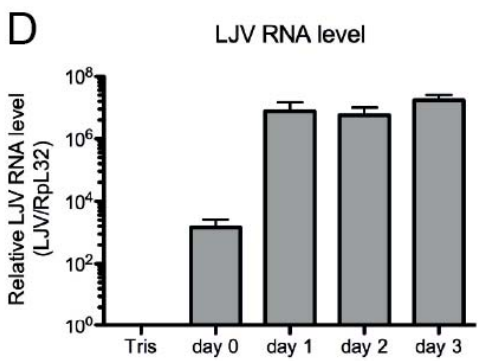


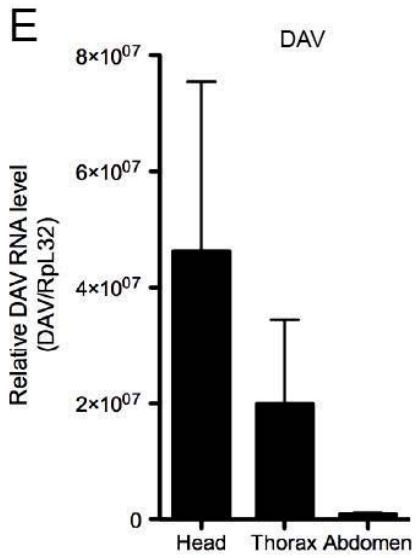


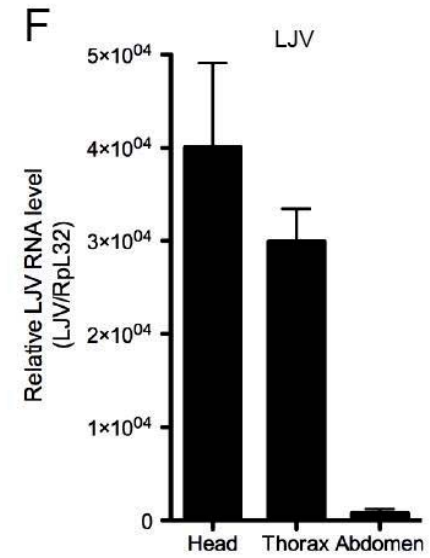












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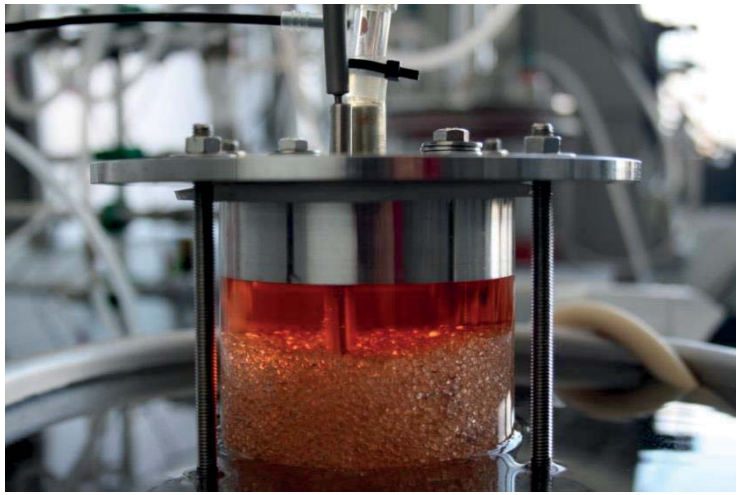
Beispiel neue Viren gegen *Drosophila suzukii*



Prof. Dr. Peter Czermak
Institut für Bioverfahrenstechnik und Pharmazeutische Technologie
Technische Hochschule Mittelhessen

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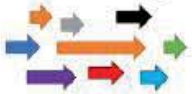
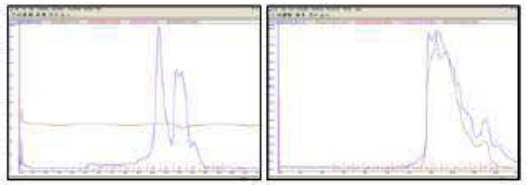
Fraunhofer IME

Gezielte Suche nach neuen Insektiziden: Animal Venomics

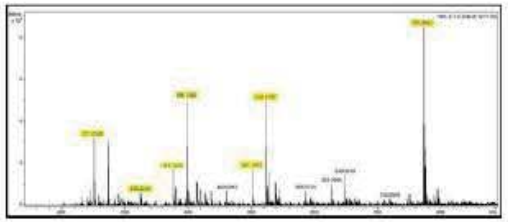
Fokus auf in silico Vorhersage



Gift Extraktion

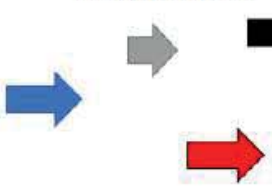


SEC-FPLC Gelfiltration

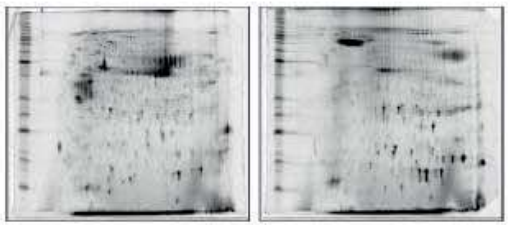


Identifikation der molekularen Massen

In vitro verifizierte Kandidaten



Fokus auf in silico Vorhersage



SDS-PAGE Massentrennung

Bioassay Aktivitätstest

Gezielte Suche nach neuen Insektiziden: Animal Venomics

toxins

MDPI

Article

Orally Delivered Scorpion Antimicrobial Peptides Exhibit Activity against Pea Aphid (*Acyrthosiphon pisum*) and Its Bacterial Symbionts

Karen Luna-Ramirez [1,†], Marisa Skaljac [1,†], Jens Grotmann [1], Phillipp Kirfel [1] and Andreas Vilcinskas [2,*]

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2 Institute for Insect Biotechnology, Justus Liebig University of Giessen, Heinrich-Buff-Ring 26-32, 35392 Giessen, Germany

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† These two authors contribute equally to this work.

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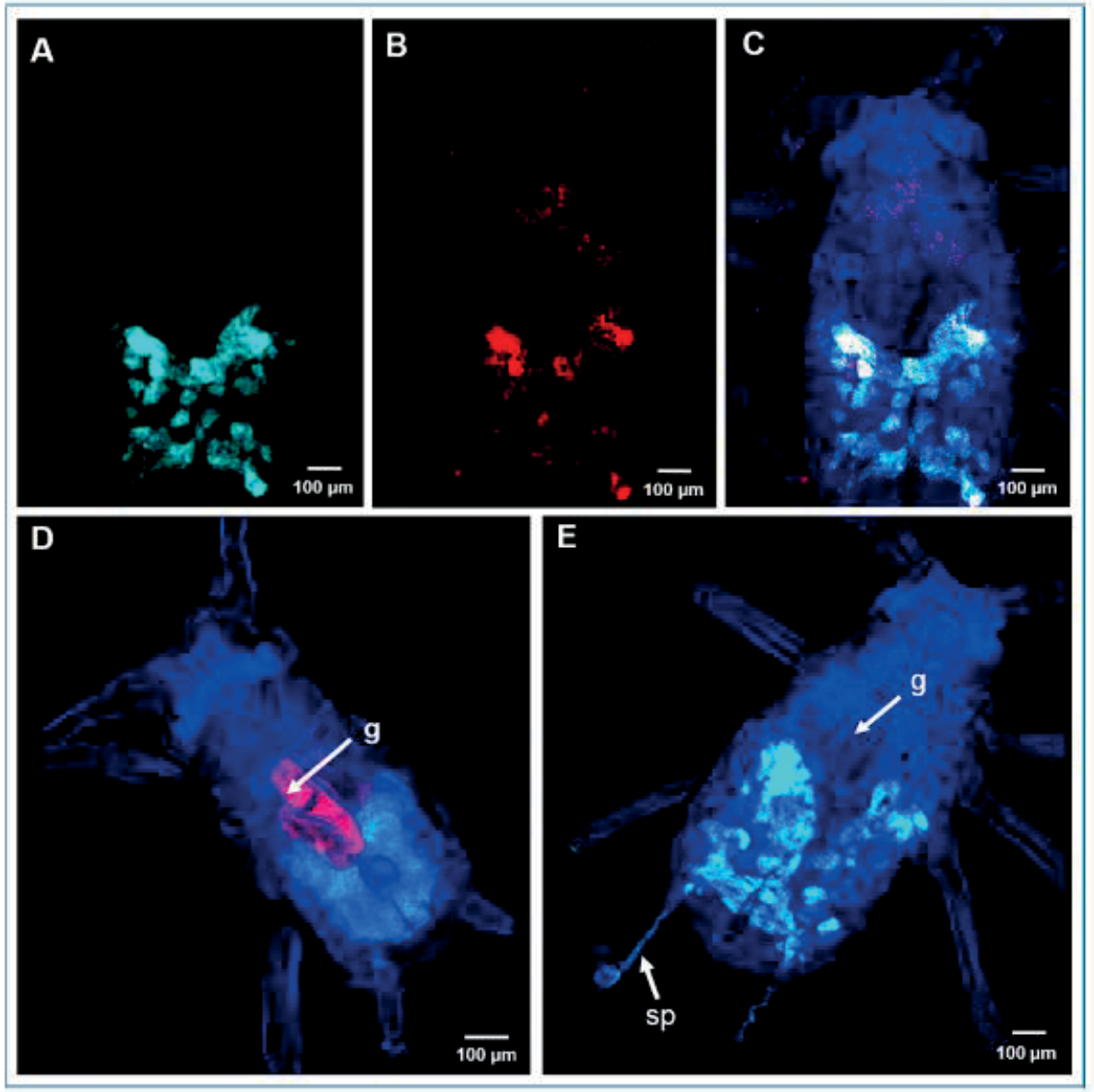
Abstract: Aphids are severe agricultural pests that damage crops by feeding on phloem sap and vectoring plant pathogens. Chemical insecticides provide an important aphid control strategy, but alternative and sustainable control measures are required to avoid rapidly emerging resistance, environmental contamination, and the risk to humans and beneficial organisms. Aphids are dependent on bacterial symbionts, which enable them to survive on phloem sap lacking essential nutrients, as well as conferring environmental stress tolerance and resistance to parasites. The evolution of aphids has been accompanied by the loss of many immunity-related genes, such as those encoding antibacterial peptides, which are prevalent in other insects, probably because any harm to the bacterial symbionts would inevitably affect the aphids themselves. This suggests that antimicrobial peptides (AMPs) could replace or at least complement conventional insecticides for aphid control. We fed the pea aphids (*Acyrthosiphon pisum*) with AMPs from the venom glands of scorpions. The AMPs reduced aphid survival, delayed their reproduction, displayed in vitro activity against aphid bacterial symbionts, and reduced the number of symbionts in vivo. Remarkably, we found that some of the scorpion AMPs compromised the aphid bacteriome, a specialized organ that harbours bacterial symbionts. Our data suggest that scorpion AMPs holds the potential to be developed as bio-insecticides, and are promising candidates for the engineering of aphid-resistant crops.

Keywords: *Acyrthosiphon pisum*; scorpion toxins; symbiosis; antimicrobial peptides



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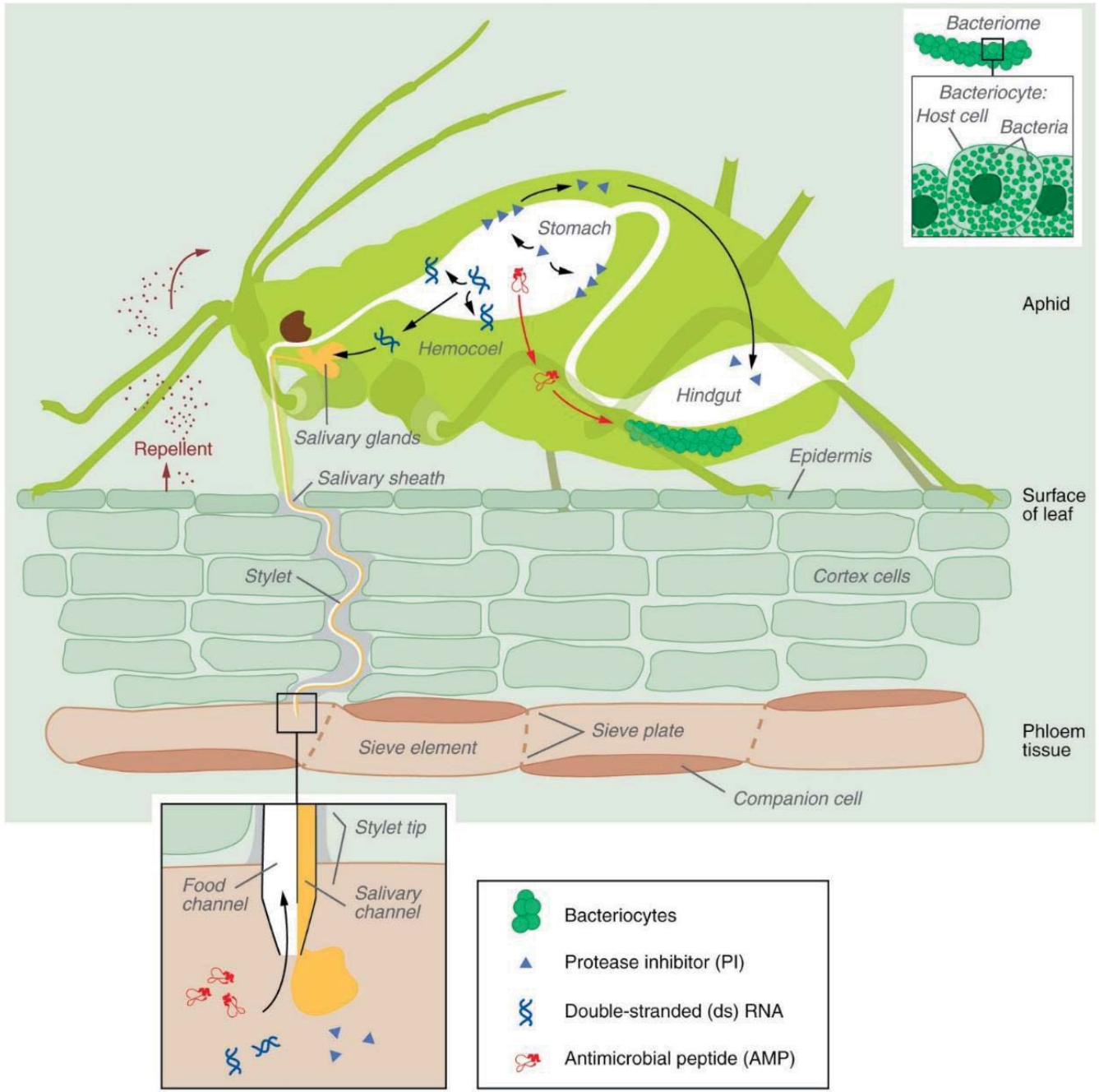
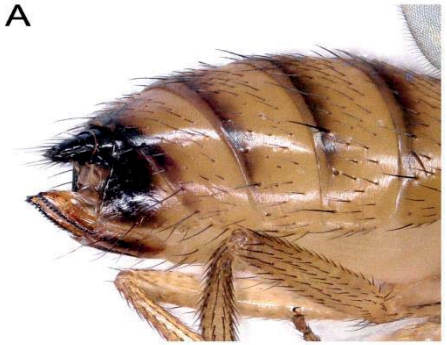
Gezielte Suche nach neuen Insektiziden: Animal Venomics

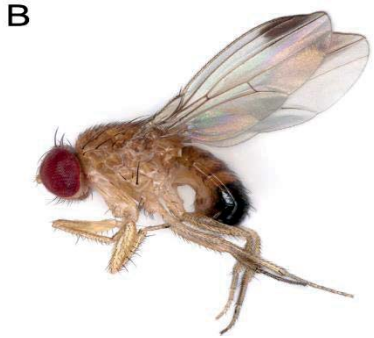


Insektenbiotechnologie und die Zukunft des Pflanzenschutzes in Deutschland

Was brauchen wir in Deutschland?

- Mehr translationale Forschung
- Entwicklung von Produkten / Dienstleistungen
- Spitzentechnologien
- Innovationen
- Stammsammlung für den biologischen Pflanzenschutz
- Wissenschaftliche Exzellenz
- Verbesserung des Lehrangebotes





Wissenschaftliche Exzellenz: Nachwuchsgruppen im ZIB

LOEWE Zentrum für Insektenbiotechnologie & Bioressourcen

- Prof. Dr. Marc Schetelig — Emmy-Noether-Programm DFG/ Fraunhofer Attract
- Dr. Georg Petschenka — Emmy-Noether-Programm DFG
- Dr. Johannes Stökl — DFG Heisenberg-Stipendiat
- Dr. Karina Brinkrolf — Fraunhofer
- Dr. Marisa Skaljac — Industrie
- Dr. Sandra Steiger — DFG-Heisenberg-Stipendiatin
- Dr. Gerrit Joop — Volkswagen-Stiftung

DFG Priority Program host-parasite coevolution

Emmy Noether-Programm
Deutsche Forschungsgemeinschaft DFG

Heisenberg-Programm
DFG Deutsche Forschungsgemeinschaft

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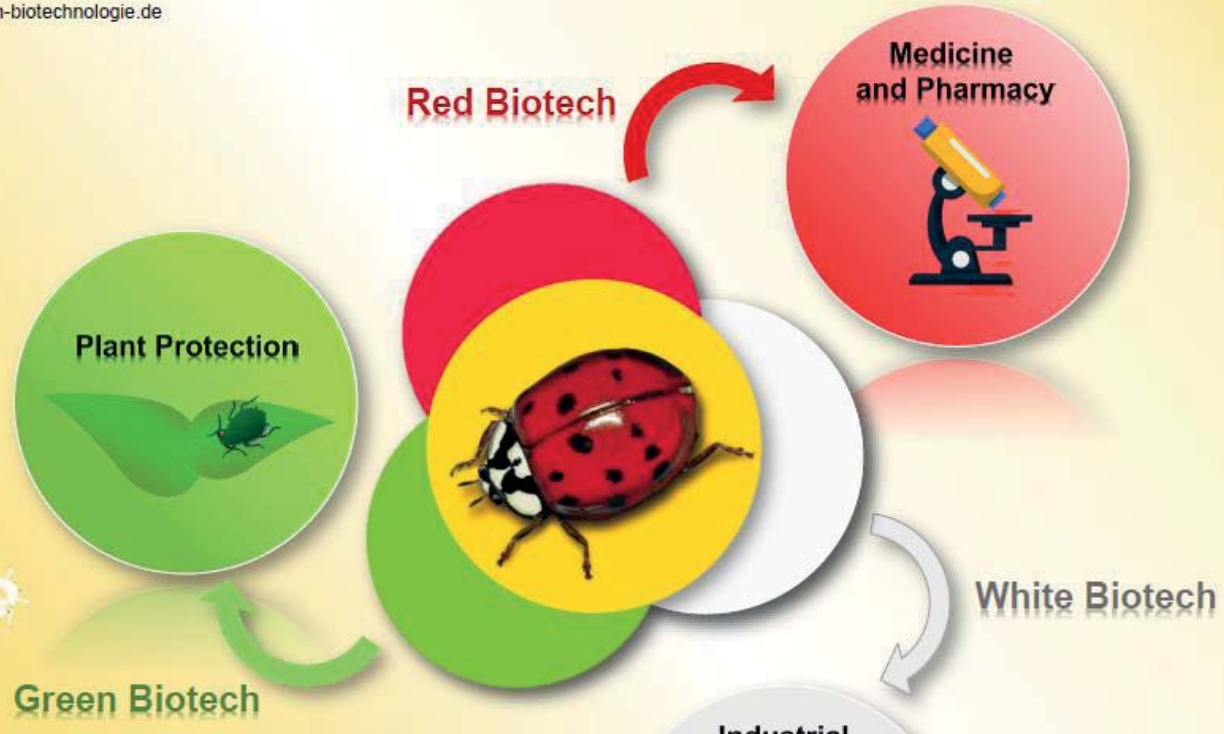

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The English Master's study program Insect Biotechnology and Bioresources boasts a unique combination of emerging disciplines:

- Combination of profession-orientated training and scientific research in the fields of entomology, agriculture, natural product research, food technology, and bioprocess engineering

Structure of the Master Program

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The course consists of eight mandatory core modules:

- Bioprocess Engineering I
- Biostatistics and Experimental Design
- Entomology I
- Entomology II
- Food Technology
- Integrated Pest Management
- Natural Product Chemistry
- Natural Product Discovery Platforms

TOPICS

Insect biotechnology in:

- Plant protection and vector control
- Natural product research
- Biochemical engineering and bioprocessing
- Evolutionary ecology

Yellow Biotechnology

at the interface of:

- **Red Biotech**
  Medicine and pharmacology
- **Green Biotech**
  Plant protection
- **White Biotech**
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Faculty of Agricultural Sciences, Nutritional Sciences and Environmental Management
www.uni-giessen.de/studium/master/IBB

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REGISTRATION

The symposium is free and open to the public with mandatory online registration at:

insekten-biotechnologie.de/de/registrierung

Registration deadline: 31 August 2017

VENUE

The symposium will be held at the **Justus-Liebig-University Gießen**

Address:
Main building,
JLU Gießen, Aula
Ludwigstr. 23
35392 Gießen

Foto: JLU-Pressestelle/Franz Müller

Parking:
There is a parking area at the main building.
Direct access is only possible from Stephanstraße.

CONTACT

ZIB LOEWE Center for Insect Biotechnology & Bioresources

Heinrich-Buff-Ring 26-32
35392 Gießen

Email: event@insekten-biotechnologie.de

www.insekten-biotechnologie.de

LOEWE - ZIB

ZIB LOEWE Center for Insect Biotechnology & Bioresources

1st Gießen Symposium of

Insect Biotechnology

9-10 October 2017

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Herzlichen Dank an die Mitarbeiter im LOEWE-Zentrum für Insektenbiotechnologie und Bioressourcen

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