WAGENINGEN UNIVERSITY
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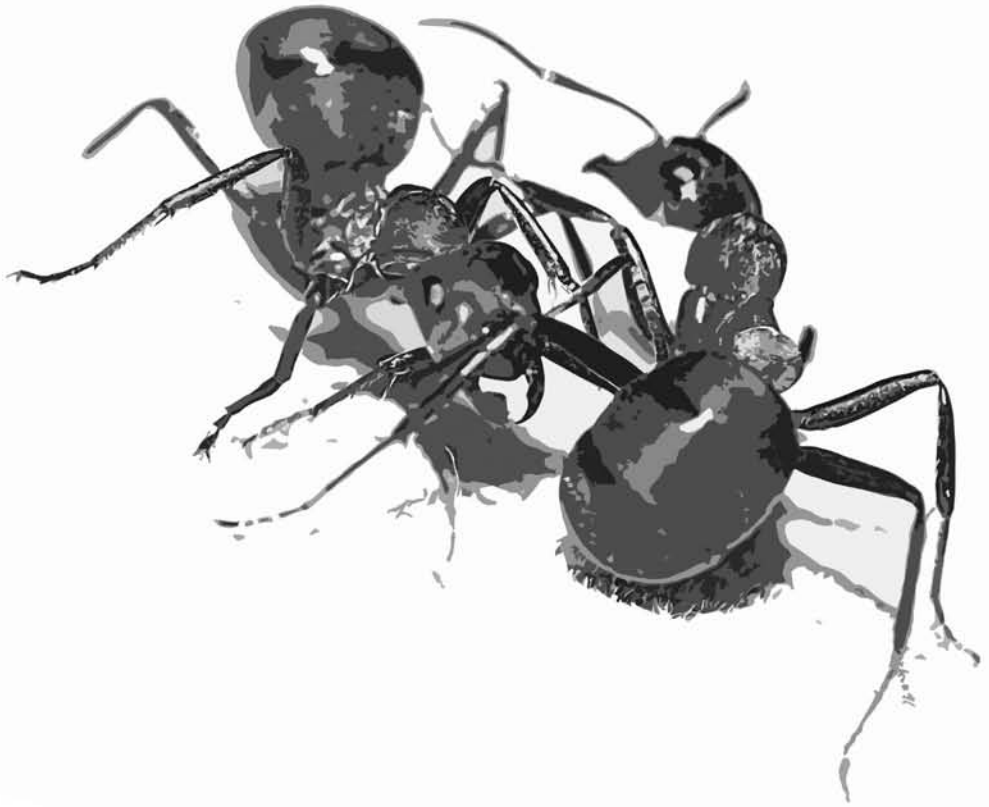
Annual report 2007
Laboratory of entomology



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ANNUAL REPORT LABORATORY OF ENTOMOLOGY 2007

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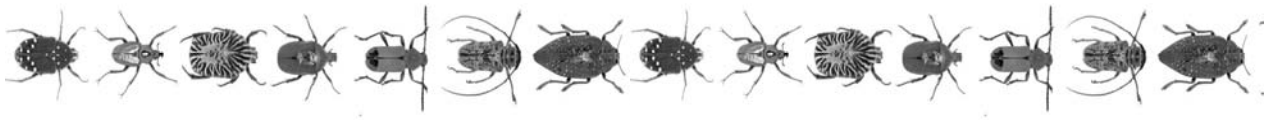

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FOREWORD

The Laboratory of Entomology of Wageningen University is an international community. In 2007 the group members represented 14 nationalities. Also the students that participate in our classes represent the international community and our research collaboration similarly spans the globe.

In 2007 we celebrated that 20 years ago research in Medical and Veterinary Entomology started at the Laboratory of Entomology. This was the start of a very successful development up till the present day.

The aim of the Laboratory of Entomology is to carry out a research and teaching programme of excellent quality that is continuously updated so as to be internationally at the forefront. The research of the laboratory of Entomology is centred around three themes: (1) chemical and molecular ecology, (2) population and behavioural ecology and (3) functional biodiversity and agroecology. Our research programmes are curiosity-driven and we exploit the knowledge obtained in developing applied programmes, especially related to the health of humans, animals and the environment. Applied research includes projects on e.g. malaria mosquitoes, integrated crop, soil, and pest management through a participatory approach and development of functional biodiversity studies to develop novel, durable, pest control strategies.
In our teaching programme we develop courses for BSc, MSc and PhD students, most of them in English, as well as for laymen so as to raise the interest of the general public for insects.

This annual report informs you about the major activities and achievements in our group in 2007. There were many memorable events.
More information about our activities, on our teaching and research programmes, on recent PhD theses, and much more can be found on our website. The URL of our website is: www.ent.wur.nl/uk.

Marcel Dicke
Head of the Laboratory of Entomology

Laboratory of Entomology

Entomology is the life science that addresses the biology of insects. The laboratory of Entomology integrates fundamental and applied aspects related to the biology of insects. Studies within the new area of environmental genomics have been initiated, combining studies of subcellular mechanisms with population- and community ecology. The fundamental research concentrates on multitrophic interactions using on the one hand molecular, sensory physiological, neurobiological and behavioural biological approaches, and on the other hand ecological, and population genetic approaches. Our strategic research focuses on finding sustainable and environmentally safe solutions to problems caused by insects in the agricultural and medical-veterinary sector in temperate and tropical zones, in collaboration with social scientists.

Position within Wageningen University and Research centre (Wageningen UR)

The Laboratory of Entomology is part of the Plant Sciences Group of Wageningen University and Research centre. All research in our group is part of the two graduate schools 'Experimental Plant Sciences (EPS)' and 'Production Ecology & Resource Conservation (PE&RC)'. The research within the graduate school EPS deals with chemical and molecular ecology as well as host plant resistance. The research within the graduate school PE&RC focuses on the ecology of bio-interactions involving plants and insects, humans and disease-transmitting-vectors, hosts and parasitoids, prey and predators, and also focuses on behavioural and population ecology, functional biodiversity and agro-ecology. The research themes in the group are closely connected and the staff members collaborate in different research themes. As a result, the research of the laboratory of Entomology is coherent and well-coordinated.

Mission and strategy

The mission of the laboratory of Entomology is to carry out excellent research and teaching in a continuously updated research programme that is nationally and internationally at the forefront and well-linked to the research of international collaborators, while working in a group in Wageningen with a very good and stimulating atmosphere and excellent internal collaboration. The group has an outstanding reputation in multitrophic interactions, biological control and malaria vector research. Multitrophic interactions will receive more attention by incorporating molecular approaches on the one hand and by engaging in research projects dealing with functional biodiversity and ecological approaches in agriculture on the other. The vector research programme is also increasingly adopting molecular approaches. Molecular ecology will continue to receive major emphasis with more attention to mechanisms at the molecular level and by using molecular techniques in the study of ecological processes. In our tropical research programme, cooperation with social sciences ensures that societal stakeholders are included in the research process, and that research is centred around the needs and opportunities of farmers.

2007

In 2007 there were many highlights. Marcel Dicke was one of the four laureates of the NWO Spinoza Award for his ecological research into the interactions between plants and insects. The Spinoza Award is also known as the 'Dutch Nobel Prize'. The prize is the biggest Dutch award in science. Each researcher receives one-and-a-half million euros to freely devote to his or her research. The researchers receive the prestigious prize for their outstanding, pioneering and inspiring scientific work. Marcel Dicke was the first ecologist and the first staff member of Wageningen University to receive this prestigious prize. Willem Takken has been appointed by Wageningen University as professor on a personal chair for Medical and

Laboratory of Entomology

Level of biological integration

Community

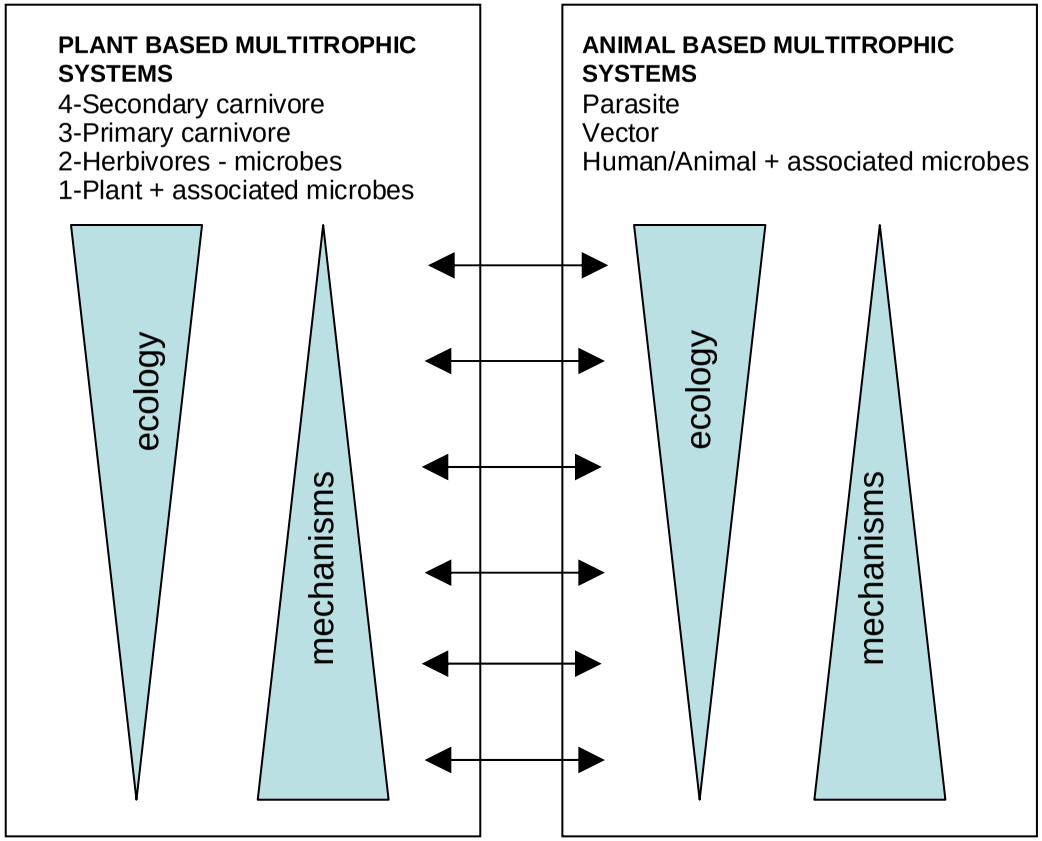
Population

Individual

Cell

Protein

Gene



Veterinary Entomology at the Laboratory of Entomology. Willem Takken and Bart Knols were awarded the Eijkman Medal for their research into the attraction of malaria mosquitoes to human body odour and Bart Knols won the UK student of the Year 2007 MBA Award.
In November 2007 it was 20 years since research into medical and veterinary entomology was initiated at the Laboratory of Entomology. This was celebrated with the festival 'Zuigers en Prikkers'. At the open day at the Laboratory of Entomology ca 1500 visitors came to see research in action and learn more about insects that feed on humans and transmit infectious diseases.

Wageningen University has attracted many more BSc and MSc students in the past few years. Many staff members of the Laboratory of Entomology are involved in informing high school students about the possibilities at Wageningen. Especially the number of Biology students is rising considerably. This will be apparent in the courses that we teach.

A total of 5 PhD students have successfully defended their theses in 2007. The scientific output in ISI journals was large with some important highlights. Martijn Bezemer published a paper in Nature on diversity and stability in plant communities. Freddy Tjallingii published a paper in the Proceedings of the National Academy of Sciences of the USA on how aphids sabotage plant defences. Hans Smid and colleagues published a paper in the Proceedings of the Royal Society London on the differences in acquisition and consolidation of long-term memory in two closely related parasitic wasps and Yu Tong Qiu and colleagues published a paper in Current Biology on molecular and physiological approaches coupled with systematic functional analyses to define the complete olfactory sensory map of the maxillaraly palp of the malaria mosquito. Two books were published: *Emerging pests and vector-borne diseases in Europe*, edited by Willem Takken and Bart Knols and a popular scientific book on insects that feed on humans, *Steken en Beten* by Willem Takken.

Communicating our research to the general public is one of our focal points in addition to communicating with the scientific community. In 2007 members of the Laboratory of Entomology were regularly in the news in interviews on TV (10), radio (20) and in newspapers (more than 35). In addition we organize a biannual lecture series 'Insects and Society' on how insects are part of our daily lives, often in beneficial ways.

Photo: Hans M. Smid

TEACHING

GENERAL

The laboratory of Entomology is involved in teaching to BSc, MSc, and PhD students. The BSc and MSc teaching relates mainly to the programmes of Biology and Plant Sciences, but also involves students in Animal Sciences, Biological Production Sciences, Molecular Sciences, Organic Agriculture and Environmental Sciences. The staff of the laboratory of Entomology teaches the following courses:

- Analysis and Prevention of Health Risks in the Tropics
- Bee Keeping
- Biology and Management of Plant Pathogens, Pests and Weeds I
- Biology and Management of Plant Pathogens, Pests and Weeds II
- Biosystematics and Biodiversity
- Cutting Edge Ecology
- Ecological Aspects of Bio-interactions
- Ecology I & II
- Ecophysiology of plants
- Evolutionary Biology
- Frontiers of Medical and Veterinary Biology
- Fundamental and Applied Aspects of the Biology of Insects
- Insect-Plant Interactions
- Insects and Society
- Molecular and Evolutionary Ecology
- Molecular Aspects of Bio-interactions
- Plant- and Crop Sciences I
- Plant- and Crop Sciences II
- Population Ecology

Teaching to PhD students is done through the teaching programmes of the Graduate Schools Experimental Plant Sciences (EPS:http://www.graduateschool-eps.info) and Production Ecology and Resource Conservation (PE&RC:http://www.dpw.wageningen-ur.nl/PEenRC).

In the academic year 2006/2007 a total of 16 students finished their MSc-thesis under the supervision of the staff of the Laboratory of Entomology.

MSC THESES 2007

- Boer de, Floor - The population structure of the flea beetle *Phyllotreta nemorum* studied by use of microsatellites - 07.03
- Elsen van den, Floor - Induction of resistance by non-pathogenic *Pseudomonas fluorescens* in plants (*Brassica oleracea* L.) upon herbivory of insects: determining direct and indirect plant resistance in a behavioural and molecular approach - 07.15
- Elven van, Joke - Do *Trichogramma* evanescens wasps specifically hitch-hike with mated female *Pieris rapae* butterflies? - 07.18
- Farenhorst, Marit - Developing a delivery method for the entomopathogenic fungus *Metarhizium anisopliae* against the African malaria mosquito *Anopheles gambiae* s.s. Giles - 07.12

- Franchimon, Wendy - Host plant preference of *Phyllotreta nemorum* - 07.02
- Hoedjes, Katja - The role of PKG expression on larval mobility of parasitoid wasps: A Comparison of *Cotesia glomerata* and *Cotesia rubecula* - 07.24
- Hoetmer, Arno - Small mammals, *Ixodes ricinus* populations and vegetation structure in different habitats in the Netherlands - 07.08
- Keser, Lidewij - Inbreeding depression in *Solanum carolinense* - 07.22
- Kos, Martine - Testing the "usurpation hypothesis" with the secondary hyperparasitoid *Lysibia nana* - 07.10
- Oduor, Ayub - Identification of electro-physiologically active compounds in four sepcies of stink bug (*Heteroptera*) - 07.14
- Paalhaar, Janneke - In-hive pollen transfer between bees enhances cross-pollination of plants - 07.01
- Prekatsakis, Georigios - Effects of variation in plant defenses on the behaviour and the development of the parasitoid *Cotesia glomerata* - 07.13
- Tribuhl, Silja - Comparative study on memory phases in the parasitic wasps *Cotesia glomerata* and *Cotesia rubecula* - 07.05
- Velzen van, Robin - Evolution of host-plant use in *Cymothoe* (Nymphalidae) feeding on *Rinorea* (Violaceae) - 07.04
- Vredenbregt, Peter - The significance of two homoterpenes and a sesquiterpene in attracting parasitoids, using *Arabidopsis thaliana* as model plant - 07.11
- Zhang, Zhao - Do Cotesia parasitoid wasps discriminate cabbage plants infested by parasitized or unparasitized *Pieris* larvae? Studies on parasitoid behavior and gene expressions - 07.07

PHD THESES 2007

A total of 5 PhD theses were completed and successfully defended:

- Alvarez, A.E. (2007): Resistance mechanisms of *Solanum* species to *Myzus persicae*. Promotor: Prof.dr. M. Dicke and co-promotors Dr. W.F. Tjallingii and Dr. B. Vosman.
- Burgio, G. (2007) The role of ecological compensation areas in conservation biological control. Promotor: Prof.dr.J.C. van Lenteren
- Oosten van, V.R. (2007): Induced pathogen and insect resistance in Arabidopsis: Transcriptomics and specificity of defense. Promotors: Prof.dr. M. Dicke, Prof.dr.ir. C.M.J. Pieterse, and Prof.dr.ir. L.C. van Loon
- Reudler Talsma, J.H. (2007): Costs and benefits of iridoid glycosides in multitrophic systems. Promotor: Prof.dr. L.E.M. Vet, and co-promotors Dr. J.A. Harvey and Dr. A. Biere.
- Soler Gamborena, R. (2007): Plant-mediated multitrophic interactions between aboveground and belowground insects. Promotors: Prof.dr. L.E.M. Vet, Prof.dr. W.H. van der Putten and co-promotor Dr. J.A. Harvey.

PhD students (1 January 2008)	short title (graduate school)	period	promotor/copromotor
1. Allema, B.	Biological control by predators, dispersal behaviour, habitat mosaics in ecological networks (PE&RC)	07-11	van Bruggen/van Lenteren
2. Berg, M. van den	Neurons involved in natural differences in associative olfactory learning in insect brains (PE&RC)	05-09	Dicke/Vet/ Smid
3. Bolckmans, K.	Evaluation, natural enemies (PE&RC)	05-09	v.Lenteren
4. Bouman, E.	Ecology of ticks	05-09	v.Lenteren
5. Broekgaarden, C.	Identification and expression of *Brassica* genes related to herbivory (EPS)	04-08	Dicke/Vosman
6. Bruinsma, M	Plant volatiles, phenotypic changes, interactions with community members (EPS)	04-08	Dicke/van Loon
7. Bukhari, T.	Entomopathogenic fungi for the control of malaria and dengue vectors (PE&RC)	07-11	Takken/Knols
8. Burns, M.	Emergency sheeting for malaria control	02-09	Dicke/Takken
9. Dannon, E.	Biology and ecology of *Apanteles taragamae* for control of *Maruca vitrata* (PE&RC)	07-11	Dicke/van Huis
10. Farenhorst, M.	Entomopathogenic fungi for the control of malaria vectors (PE&RC)	07-11	Takken/Knols
11. Gassner, F.	Ticks, *Borrelia* infections, fitness (PE&RC)	06-10	Takken/Dicke
12. Giessen, W.A. van	Sensory physiology aphids (EPS)	00-07	v.Lenteren/v. Loon
13. Gols, R.	Linking (in-)direct plant defences in cultivated Brassicaceae to wild relatives (PE&RC)	04-08	Dicke
14. Helinski, M.	Reproductive biology, induced sterility and genetic control of mosquitoes (PE&RC)	04-08	Dicke/Knols
15. Hiwatt, H.	Monitoring malaria intervention methods (PE&RC)	06-10	Dicke/Takken
16. Huang, Y	Risks of importation of exotic organisms (extern, Univ. Beijing)	99-07	v. Lenteren/ Xu Rumei
17. Hulshof, J.	Biocontrol of western flower thrips with predators (PE&RC)	00-07	v. Lenteren/Sabelis/Janssen
18. Imbahale, S.	Water management systems, traditional agriculture, malaria mosquitoes (PE&RC)	05-09	Dicke/Takken
19. Jumbe, M.	Entomopathogenic fungi and control of malaria vectors	07-11	Wijffels/Takken/Dicke
20. Kos, M.	Ecological effects of plant resistance traits on non-target organisms in crucifers (EPS)	07-11	Dicke/Vet/van Loon
21. Leur, H. van	Molecular, phytochemical, ecological aspects glucosinolate polymorphism (EPS)	04-08	Vet/vd Putten/v.Dam
22. Lof, M.	Spatio-temporal modelling infochemicals in food web context (PE&RC)	04-09	Dicke/Hemerik/d.Gouw
23. Lommen, S.	Wingless ladybirds and biological control of aphids (extern)	04-08	Brakefield/de Jong
24. Maxwell, C.	Low technology methods of mosquito vector control (extern)	02-08	v. Lenteren/Takken
25. Mwingira, V.	The chemical ecology of mosquito oviposition behaviour (PE&RC)	06-10	Dicke/Takken
26. Ng'habi, K.	Genetic variability malaria mosquitoes (PE&RC)	06-09	Dicke/Knols
27. Nguessan, R.	Insecticide resistance, *Anopheles gambiae,* investigation of alternative strategies for its delay (PE&RC)	06-09	Dicke/Knols
28. Ochieno, D.	Enhancing plants with endophytes: potential for ornamentals?	06-10	Dicke/v.Huis/Dubois
29. Ondiaka, S.	Behavioural and ecological effects of fungal infection in adult malaria mosquitoes in Kenya (PE&RC)	07-11	Dicke/Knols
30. Paaijmans, K.	Micrometeorology and life history of African malaria mosquito larvae (PE&RC)	03-07	Holtslag/Dicke/Takken/Jacobs
31. Poelman, E.	Linking plant defence to higher trophic level biodiversity (EPS)	04-08	Dicke/Vet/v.Loon/v.Dam
32. Raak-van den Berg, L.	Harmonia, aphid control, risk analysis (PE&RC)	07-11	van Lenteren/de Jong
33. Ravensberg, W.	Evaluation, natural enemies (PE&RC)	05-09	van Lenteren
34. Sauers-Müller, A. van	Behaviour, carambola fruitfly (PE&RC)	00-07	van Lenteren
35. Snoeren, T.A.L.	Plant volatiles, genotypic variation, interactions with community members (EPS)	04-09	Dicke
36. Suer, R.	Olfaction in the malaria mosquito, *Anopheles gambiae*: electrophysiology and morphology (PE&RC)	06-10	Dicke/van Loon/Takken
37. Sznajder, B.	Phenotypic plasticity, predatory mites (extern)	02-07	Sabelis/Dicke
38. Toleubayev, K.	Crop protection perspectives in Kazakhstan (Ceres)	04-09	v.Huis/Leeuwis
39. Trautsch, J.	Terpenoids in plant-mite interactions	06-10	Dicke/Gershenzon
40. Trefas, H.	Intercropping, beetles (PE&RC)	01-07	van Lenteren
41. Verhulst, N.	Disruption of malaria transmission, chemical manipulation of Anopheline olfactory responses (PE&RC)	06-10	Dicke/Takken
42. Vermeer, K.	Ecogenomics of host plant use in a phytophagous insect (PE&RC)	07-11	Dicke/de Jong
43. Wanzala, W.	Ethnobotanicals used for ectoparasites control in traditional livestock (PE&RC)	04-08	v. Lenteren/Takken
44. Yang Limei	Arabidopsis molecular biology *Plutella* and *Cotesia* (EPS)	01-07	Dicke/van Loon/Jongsma
45. Yayima, M.	Cassava and poverty alleviation in Malawi (Ceres)	04-09	v.Huis/Jiggins
46. Zhou, D.S.	Molecular basis of phenotypic plasticity of taste in insects (EPS)	05-09	Dicke/van Loon

RESEARCH PROGRAMME

The laboratory of Entomology investigates interactions between arthropods on the one hand and plants, animals and humans on the other. Our research aims at improving the understanding of multitrophic interactions in natural and agro-ecosystems and at (i) developing environmentally benign crop protection, (ii) improving health of animals and humans and (iii) conserving natural resources. The research relates both to temperate and tropical systems. The main focal points of our research are:

- chemical and molecular ecology
- behavioural and population ecology and
- functional biodiversity and agroecology.

Through both experimental and model approaches we address (a) the mechanisms that insects use to locate and evaluate their food sources and that plants and animals use to defend themselves against insects; (b) the causes of population fluctuations and differences in genetic composition among populations; (c) molecular aspects that underlie processes, interactions and evolutionary changes; (d) functional aspects of the characteristics of particular insect species and (e) the role of biodiversity in durable agriculture.

Our fundamental research concentrates on multitrophic interactions. On the one hand we investigate mechanisms of interactions, e.g. through molecular, sensory physiological and behavioural approaches. On the other hand ecological aspects of multitrophic interactions are investigated, through e.g. population genetical, population ecological and model approaches.

The applied research especially aims at finding durable and environmentally benign solutions to problems that are caused by insects. This relates to research on insects in common agricultural practices and in organic agriculture as well as in medical-veterinary problems.

All research of the laboratory of Entomology participates in the graduate schools *Production Ecology and Resource Conservation* (PE&RC - http://www.dpw.wageningen-ur.nl/PEenRC/index/index.htm), *Experimental Plant Sciences* (EPS - http://www.graduateschool-eps.info/) and Resource Studies for Development (*CERES*).

Progress in the research programmes is presented below:

Chemical and sensory ecology

Joop J.A. van Loon, Hans M. Smid; Yu Tong Qiu, Maaike Bruinsma, Erik H. Poelman, Wilant van Giessen, Dongsheng Zhou, Limei Yang, Richard J. Hopkins, Martine Kos

The defence response of Brussels sprouts (*Brassica oleracea* L.) plants was induced by exogenous application of jasmonic acid (JA), a crucial hormone in the octadecanoid plant defence signaling pathway. JA treatment was used to manipulate volatile emission of the plant, known to affect host-location behaviour of parasitoid wasps that are important components of plant indirect defence. Three species of parasitoid wasps, differing in host range and host specificity, were tested for their behavioural responses to herbivore-induced, JA-induced and non-induced plants. All three species were attracted to JA-induced plants compared to control plants; however, they preferred herbivore-induced plants over JA-induced plants. The parasitoid *Cotesia glomerata* (L.) (Hymenoptera: Braconidae) was attracted to the plants within a few hours after JA-induction, and the plants remained attractive to the parasitoids for more than five days, whereas herbivore-induced plants did not attract parasitoids five days after removal of the herbivores. We conclude that although JA-application has the advantage of quantitatively controlling the strength of induction, it does not fully mimic

actual herbivore feeding in terms of parasitoid response and volatile emission. We investigated the relationship between parasitoid load of the gregarious *C. glomerata*, food consumption by larvae of their host *Pieris brassicae* L. (Lepidoptera: Pieridae), and seed production in a hostplant, *Brassica nigra* L. (Brassicaceae), in a greenhouse experiment. Plants damaged by caterpillars containing single parasitoid broods produced a similar amount of seeds as undamaged control plants and produced significantly more seeds than plants with unparasitised caterpillars feeding on them. Increasing parasitoid load to levels likely resulting from superparasitisation, feeding by parasitised caterpillars was significantly negatively correlated with plant seed production. Higher parasitoid brood sizes were negatively correlated with pupal weight of *C. glomerata,* revealing scramble competition leading to a fitness trade-off for the parasitoid. We conclude that in this tritrophic system plant fitness is higher when the gregarious parasitoid deposits a single brood into its herbivorous host.

Photo: Nina Fatouros

Ecology, evolution and genetics of interactions between phytophagous insects, their host plants, and their enemies.

Peter W. de Jong, Patrick Verbaarschot, Kim Vermeer, Keiko Oku, S. Lommen (Leiden), Lidwien Raak-van den Berg

The interactions between phytophagous insects, their host plants, and their enemies provide ideal opportunities to study the ecology, evolution and genetics of adaptations in the field. The project focuses on the interaction between a flea beetle, its (natural) cruciferous host plants, and its enemies. In collaboration with Dr. Kamimura (Tsukuba, Japan) we have applied a candidate gene approach to characterise the resistance genes at the molecular level. It is thought that beta-glucosidases are responsible for the different resistance genotypes and we have addressed this genetic basis of resistance. Sampling the flea beetle populations in Denmark that had been earlier sampled (1997) showed that the frequencies of resistant flea beetles on other plants than *Barbarea* are decreasing. Analysis of population structure of the flea beetles with allozymes has shown that different resistance-phenotypes are genetically differentiated. In 2006-2007 one new aspect of this phytophagous insect-host plant interaction was added, namely the possible presence of "enemy free space" on *Barbarea*. Also, new methods have been developed to study host plant acceptance/-preference of the flea beetles, and pilots have been carried out.

Next to the work on the flea beetles, work has been carried out with the two spot ladybird beetle. This work is done in collaboration with the Intitute of Biology in Leiden (group of Prof. P.M. Brakefield), and involves the use of wingless two-spot ladybird beetles in biocontrol of aphid-pests. Simultaneously, we have

monitored natural ladybird populations to detect changes in gene-frequencies involved in colour polymorphism in ladybirds, possibly associated with climatic change. Finally, we have started monitoring the invasion of The Netherlands by the asian ladybird beetle, *Harmonia axyridis*.

Infochemicals in multitrophic interactions

Marcel Dicke, Rieta Gols, Adriana Alvarez, Michaël van den Berg, Colette Broekgaarden, Maaike Bruinsma, Tibor Bukovinszky, Elie Dannon, Nina E. Fatouros, Ties Huigens, Iris Kappers, Martine Kos, Marjolein Lof, Roland Mumm, Dennis Ochieno, Vivian van Oosten, Erik Poelman, Tjeerd Snoeren, Janett Trautsch, Limei Yang, and Si-Jun Zheng.

A major challenge for current biology is to integrate research approaches that address different levels of biological organization: i.e. from subcellular mechanisms to functions in ecological communities. An important question in plant defense-signaling research is how plants integrate signals induced by pathogens, beneficial microbes and insects into the most appropriate adaptive response. In this program we address ecological interactions and the underlying mechanisms. Most of the research focuses on multitrophic systems consisting of brassicaceous plants, their herbivores and associated carnivorous arthropods. In addition we address other plants, such as cucumber, banana and cowpea, especially for applied projects.
In 2007 we have made important progress in linking molecular genetics to community ecology. By exploiting the molecular toolbox for *Arabidopsis*, the model plant for molecular genetics, we have investigated the relative involvement of different sub-pathways within the octadecanoid signal transduction pathway in induced indirect plant defence as mediated by herbivore-induced plant volatiles. We have addressed this at the level of (bio)chemical and behavioural analyses by using different plant mutants that are compromised in specific steps in the signal-transduction pathways. This is linked to research in *Brassica* where we exploited the availability of elicitors and inhibitors of different steps in the octadecanoid pathway. Octadecanoid pathway mediated plant responses affect herbivores such as *Pieris* butterflies and their *Cotesia* parasitoids. Ecological research on *Brassica oleracea* plants in the laboratory and the field has shown that induced direct defence, mediated by glucosinolates, is expressed at higher levels in natural populations than in cultivars. Glucosinolates especially affect the performance of generalist herbivores negatively and induced defence in *Brassica* plants affects the composition of the associated insect community, resulting in a community that consists of relatively more specialists than generalists. The first *Brassica* genes underlying such responses have been identified.
Induced defences of *Brassica* plants differentially affect specialist and generalist herbivores and this may result in trade-offs to plants related to defences that are effective against these different types of herbivores. Other trade-offs may include a trade-off between defence and reproduction that is mediated by pollinators. Plants that invest in induced indirect defences may be less attractive to pollinators.
By integrating approaches at different levels of biological integration, from genes to communities we integrate knowledge on ecological interactions and the underlying mechanisms. This is valuable to develop novel methods of durable pest control.

Evolutionary Ecology
Louise E.M. Vet, Hans M. Smid, Joanneke Talsma, Roxina Soler, Hanneke van Leur, Erik Poelman, Michaël van den Berg. At NIOO in close collaboration with Wim van der Putten, Jeff Harvey, and Nicole van Dam.

The research focuses on the ecology and evolution of multitrophic systems of plants, herbivorous insects and their natural enemies. We use a multitude of approaches to study the functioning of natural enemies in

a spatially and (fyto)chemically diverse world. The behavioural ecological work investigates evolutionary aspects of phenotypic variation in foraging and life history traits. The chemical ecological approach focuses on the mechanism and function of chemical information conveyance between plants, herbivores and natural enemies and the influence of plant defence on the diversity, behaviour and performance of higher trophic levels. In addition we study neurobiological aspects, specifically information processing (learning and memory) of herbivore-induced plant volatiles by insect parasitoids.
We addressed differences in learning rate and LTM consolidation between *C. glomerata* and *C. rubecula*. We found that *C. glomerata* forms LTM after a single oviposition experience, whereas *C. rubecula* needs three spaced oviposition experiences before LTM is formed. If both wasp species receive three spaced oviposition experiences, *C. glomerata* consolidates LTM within 4 hrs, whereas *C. rubecula* takes 3 days before LTM is completely consolidated. We interpreted this difference in consolidation speed as a difference in the time window that that is used to evaluate additional experiences before information is stored as LTM. We currently study this idea further by creating selection lines of *C. glomerata* that are different in learning rate and consolidation speed.
The memory gene CREB (camp responsive element binding protein) was studied to test our hypothesis that differential expression of CREB is correlated with different levels of learning rate in *Cotesia*. Brain homegenates of both wasp species were prepared from naïve- and of series of experienced females, and expression of several different CREB transcripts was determined using real time quantitative PCR. Data analysis is in progress.

Tropical entomology
Arnold van Huis, Jeroen Spitzen, Elie Dannon, A. Hoetmer, Dennis Ochieno, K. Toleubayev, M. Yajima

The project on the effects of crop management on performance of endophytic *Fusarium* spp. in tissue culture banana against the banana weevil *Cosmopolites sordidus* (Germar) and nematodes in Uganda focuses on the potential of endophytes in crop protection. The focus is on soil characteristics and their effects on plant-endophyte-nematode and plant-endophyte-bananaweevil interactions.
In Benin a new project focuses as of 2007 on the potential of the parasitoid *Cotesia taragamae* for biological conrol of a key pest of cowpea, i.e. *Maruca vitrata*. The central focus of the present project is to provide basic information on the biology and ecology of *A. taragamae* with emphasis on some key aspects of the bioecology of the parasitoid related to the effect of host plant quality on its biology, the influence of host age, density, temperature and relative humidity on its biology, host searching behaviour of the parasitoid as mediated by cowpea, evaluation of environment risk of its introduction through the determination of its physiological host range and its competitive interactions with *Phanerotoma leucobasis*, an indigenous parasitoid of *M. vitrata*. The final step of the implementation of this project will be a large scale release of *A. taragamae* at selected sites followed by recovery studies.


Photo: Ruben Smit

Vector biology and control

Willem Takken, Bart G.J. Knols, Jeroen Spitzen, Hans Beijleveld, Henk van den Berg, Tullu Bukhari, Gabriella Bukovinszkine, Marit Farenhorst, Fedor Gassner, Michelle Helinski, Helène Hiwat (Suriname), Susan Imbahale (Kenya), Frans Jacobs, Victor Mwingira (Tanzania), Kija R. Ng'habi (Tanzania), Krijn P. Paaijmans, Sophie Ondiaka, Yu Tong Qiu, Renate C. Smallegange, Remco A. Suer, Niels Verhulst, Wycliffe Wanzala (Kenya)

Our research focuses on the chemical ecology of mosquitoes, the ecology of aquatic stages of malaria vectors, the development of entomopathogenic fungi for malaria vector control and the population biology and vector-host interactions of disease vectors in natural areas. In a broader perspective the work contributes to development of sustainable solutions for vector-borne disease control in temperate and tropical regions.

Our long-term study of mosquito olfaction focused on the identification of novel compounds from human skin by a combined study of chemical analysis, electrophysiology and behaviour in Wageningen, and behavioural studies in semi-field and field settings in Tanzania, Kenya and the Gambia. A basic odour blend of NH_3 + L-lactic acid was developed, to which candidate odours were being added for testing in laboratory and (semi)field settings. It was found that CO_2 plays a crucial role in guiding mosquitoes from a distance to the vicinity of a mosquito trap or odour port. Human skin emanations or synthetic blends, containing chemicals present on the skin, are required to draw the mosquitoes into the trap or olfactometer. Thus, strong synergy between CO_2 and skin emanations exists affecting the behavioural response of the African malaria vector *Anopheles gambiae*. This was further corroborated by the interesting identification of CO_2-specific olfactory neurons on the maxillary palpi of female mosquitoes.

Other studies undertaken by the group include water management for the control of malaria in western Kenya, integrated vector management for malaria control in West Africa, oviposition behaviour of malaria vectors in Tanzania, the ecology of malaria vectors in the tropical rainforest of Suriname, the overwintering of bluetongue vectors, the ecology of Lyme disease and the use of botanicals for tick control in agropasturalists in Kenya. Some results: (a) in western Kenya large differences in the ecology of malaria vectors were found between a peri-urban site and two highland sites. (b) in Mali we support malaria workers at the Office du Niger with curriculum development for integrated vector management. (c) studies on tick-vectors of Lyme disease in the Netherlands showed a high degree of heterogeneity associated with differences in tick densities and *Borrelia* infection rates in ticks. The *Borrelia* infection rates of ticks varied from 3 to 60% between sites.

Behaviour, gene flow and biological control of malaria mosquitoes

Bart G.J. Knols, Heather Ferguson, Kija Ng'habi (Tanzania), Marit Farenhorst, Daniela Farina, Tanya Russell, Gerry F. Killeen, Ladslaus Laurent, Frank van Breukelen, Mgeni Jumbe, Tullu Bukhari, Sophie Ondiaka, Joel Mouatcho, Chris Kikanki, Arjen Rinzema, Maureen Coetzee, Willem Takken

Behavioural and ecological determinants of gene flow in African malaria mosquitoes. Ecological and population biology issues remain challenges to the application of genetic control strategies. Similarly, molecular geneticists need to resolve pertinent issues related to gene driving systems and develop means to ensure complete linkage of the refractoriness genes to the drive system, failure of which may seriously undermine the potential of this technology. The use of contained field-based research is currently advocated to face the shortfalls in understanding of the behaviour and ecology of genetically- engineered vectors, prior to their release in the wild. A central goal of this project is to investigate ecological factors that determine gene flow in African malaria vectors under semi-field conditions. This research is conducted within a 700m^2 semi-field system, that uniquely allows experimental study of mosquito gene flow in field realistic conditions for the purpose of assessing prospects for reducing malaria transmission by using genetic control strategies and other

innovative vector control methods. In 2007, we were successful in getting a self-perptuating population of *An. arabiensis*. Furthermore, populations were sampled from across the Kilombero valley to study their genetic heterogeneity. Furthermore, a PCR test was developed to discriminate inseminated from virgin females. Finally, studies that focused on energetic reserves on wild male anophelines compared to counterpart laboratory specimens were completed. The body size and lipid reserves of wild males were substantially greater than those reared under standard laboratory conditions. We caution that the energetic limitations of insects as identified in the laboratory may underestimate their resilience in the wild.
Fungal biopesticides for the control of malaria mosquitoes. In 2007, substantial progress has been made in the development of new delivery methods for fungi to infect mosquitoes. Research on African clay water storage pots showed that anopheline infection exceeds 90% when mosquitoes rest inside such pots for periods of 6 or 17 hrs. It has also been shown that insecticide resistant strains succumb to fungal infection. New solid state fermentation methods to produce the fungus *Metarhizium anisopliae* were researched and an optimum growth substrate has been defined in the form of hemp. In Tanzania, preparations for large-scale multi-village trials have been launched and a series of experimental huts were constructed for experimental purposes.

Photo: Hans Smid

From behavioural and population ecology to functional biodiversity and agro-ecology
Joop van Lenteren, Bas Allema, Giovanni Burgio, Carmen Isabel Castillo Carrillo, Lidwien Raak-van den Berg, Sara Ruschioni, Valentina Lo Verde.

Much of our work involves (1) parasitoid behaviour and development of biological and integrated pest management programmes (Behavioural and population ecology; first paragraphs of this report), and (2) functional biodiversity and agroecology (the third research theme of the Laboratory and the second paragraph of this report).
Behavioural and population ecology:
We address the elemination of supernumerary parasitoid larvae in *Eretmocerus mundus*. Until now it was unclear whether elimination occurs when the parasitoid larvae are still outside the host (*Eretmocerus* lays its eggs between the host and the host plant), or that elimination occurs within the host after the parasitoid larvae have penetrated the host. Several cases of parasitoid larvae attacking each other outside the host were recorded. In an experiment where superparasitism was created, parasitoid mortality was higher than in once parasitized hosts, also showing elimination during the phase that the parasitoid larvae are still outstide the host. Work on the transfer of *Wolbachia* from one strain of *Eretmocerus* to another strain was initiated. Work on risk assessment of importing and releasing of exotic natural enemies was continued in collaboration with Antoon Loomans (Plant Protection Service) and has resulted in important contributions to an EC funded project on regulation of registration systems of natural enemies.

Sara Ruschioni, in a collaborative PhD project with the universities of Ancona and Perugia, studied the reaction of parasitoid ovipositors to different solutions related to host discrimination. She succeeded for the first time in history to make recordings of sensilla on the ovipositor of a parasitoid. She is now studying the fine structure of ovipositor sensillae.

Functional Biodiversity and Agroecology:

The general objective of the project on Functional Biodiversity and Agroecology is to determine how increased biodiversity leads to reduced pest development. Some of our findings are (1) that it is still too early to generalize on processes related to natural biological control in diversified agro-ecosystems, and (2) that research spanning several scales – from individual to ecosystem – is needed to evaluate the effect of diversified ecosystems on herbivore and carnivore population dynamics. Concerning point 2, we hope to come up with a new classification of herbivores and carnivores on basis of their searching behaviour. This new classification may help in formulating generalizations on pest regulation processus in diversified ecosystems.

Giovanni Burgio (University of Bologna; PhD student at Entomology Wageningen) has finished a study on the effect of the degree of biodiversity in field edges and other landscape elements on natural biological control in several crops. He defended his thesis at Wageningen University in September 2007.

PhD projects on the role of polyphagous predators in herbivore reduction and on risks of releasing the exotic polyphagous predator *Harmonia axyridis* have been started recently.

Aphid-plant interactions and host plant resistance.

W.F. Tjallingii and Adriana Alvarez.

Compatible plant-aphid combinations seem the result of a long co-evolutionary history in which the plant reacts moderately on the specialized aphid species, whereas incompatible combinations are either characterized by complete resistance of the plant to the aphid or by hypersensitive reactions that may lead to chlorosis, growth disturbance, programmed cell death, or plant death.

Within the *Solanum* genus some species appeared susceptible to *Macrosiphum euphorbiae* and *Myzus persicae*, whereas others were resistant either one or to both aphids. *S. stoloniferum* appeared resistant to *M. persicae*, which caused cell hypertrophy and death but the plant was susceptible to M. euphorbiae and showed no visible impact. Differential gene expression was studied due to colonization by both aphid species and showed that in the compatible combination far more genes were up and down regulated than in the incompatible combination, in spite of the strong local tissue reaction in the latter. Nevertheless, it seems clear that the two effects are difficult to compare as *M. persicae* is reluctant to penetrate the plant and, most likely, did not feed at all. Thus no saliva had been phloem injected and local (mesophyll) effects were more local, in contrast to a presumed systemic effect in the compatible combination.

Electrical penetration graph (EPG) recordings applied in experiments with veruliferous (cucumber mosaic virus carrying) *Aphis gossypii* aphids confirmed that inoculation occurred during the first of three waveforms shown during brief (5 sec) intracellular stylet punctures (cooperation with CSIC, Madrid). Moreover, two EPG systems were compared during this study, the original AC system (1964) and the later (1978, 1988) DC system. The systems record signals from different electrical origin reflecting partly different biological events. A device was developed that enabled recording with both systems from one aphid concurrently. Although a few aspects were clearer in the AC signals, for most other features it was the opposite thus showing that in general the DC system must be preferred.

In October an international EPG workshop/training course was organized in ZhengZhou, Ge Nan Agricultural University.

Projects within graduate school Experimental Plant Sciences:

- EPS2-2b28. Insect-plant interactions during stylet penetration by aphids. W.F. Tjallingii
- EPS2-b128. Molecular characterisation of mechanisms of *Solanum* resistance to *Myzus persicae*. Impact on PLRV transmission. 2003-2007. A.E. Alvarez, W.F. Tjallingii, B. Vosman & M. Dicke
- EPS2-2d06. Induction of plant volatiles by herbivory: signal transduction and behavioural modification in a multitrophic context. M. Dicke, R. Gols.
- EPS2-2d04. Variation in foraging behaviour of the predatory mite *Phytoseiulus persimilis*. 1992-2006. C. Schütte, M. Dicke and J.C. van Lenteren.
- EPS2-2d05. Sensory, behavioural and nutritional effects of plant substances on host plant and host insect evaluation and utilization by insects. J.J.A.van Loon, H.M. Smid.
- EPS2-2d23. Cross-talk between signal-transduction pathways in induced defence of Arabidopsis against microbial pathogens and herbivorous insects. 2001-2007. V.R. van Oosten, C.M.J. Pieterse, L.C. van Loon & M. Dicke.
- EPS2-2d27 Genomics approach to integration of host plant insect resistance and biological control. 2001-2006. L. Yang, J.J.A. van Loon, M.A. Jongsma & M. Dicke.
- EPS2-2d28. Development of a method for breeding of cucumber for improved attraction of biological control agents. 2002-2007. I.F. Kappers, L. Luckerhoff, H.J. Bouwmeester & M. Dicke.
- EPS-2c036. Phenotypic manipulation of induced plant defense in Brassica, 2004-2008. M. Bruinsma, M. Dicke, J.J.A. van Loon.
- EPS-2c037. Manipulation of plant genotype and effects on interactions with community members. 2004-2008. T.A.L. Snoeren, M. Dicke, P.W. de Jong.
- EPS-3c062. Metabolomics of indirect defence in cultivated Brassica oleracea varieties and its effects on insect biodiversity, 2004-2008. E.H. Poelman, J.J.A. van Loon, M. Dicke
- EPS-32c060. Identification and expression of genes related to herbivory, 2004-2008. C. Broekgaarden, M. Dicke, B. Vosman.
- EPS. Molecular ecology of terpenoids in plant-insect interactions. 2004-2007. R. Mumm and M. Dicke
- EPS- Molecular, phytochemical and ecological aspects of glucosinolate polymorphism. H. van Leur, W.H. van der Putten & L.E.M. Vet.
- EPS3-2c new: Development of an ecological method to evaluate the effects of GM crucifer crops, altered in direct and indirect plant resistance traits, on non-target organisms in relation to baseline information. NWO-ALW Thematic Program Environmental Risk Assessment of Genetically Modified Organisms. 2007-2011. M. Kos, J.J.A. van Loon & M. Dicke

Projects within graduate school Resource Studies for Development (CERES):

- CERES 44860. Plant Protection Perspectives in the Context of Institutional Changes in the Post-Soviet Kazakhstan, 2005- 2009. K. Toleubayev, A. van Huis & K. Jansen (chair group Technology and Agrarian Development)

Projects within graduate school Production Ecology and Resource Conservation:

- PE&RC32-00aj. Factors that affect host searching by anopheline mosquitoes. W. Takken, J. Spitzen.
- PE32-94a. Understanding biological control of whiteflies by natural enemies. J.C. van Lenteren
- PE&RC 32 03b. Temperature distribution in shallow water bodies: Influence of abiotic factors on the population dynamics of immature stages of African malaria vectors. 2003-2007. K. Paaijmans, A.F.G. Jacobs, W. Takken, A.A.M. Holtslag & M. Dicke.
- PE&RC-3204a. Spatio-temporal modelling of infochemicals in a food-web context. 2004-2008. M. Lof, L. Hemerik, M. Dicke & M. de Gouw.
- PE&RC 31 05d. Neural basis of associative learning in two closely related Cotesia parasitoid wasp species. 2005-2009. M. van den Berg, H.M. Smid, J.J.A. van Loon and M. Dicke.
- PE&RC The contribution of landscape elements to natural pest control. G. Burgio, J. van Lenteren
- PE&RC new: Behaviour and elimination of supernumerary parasitoid larvae in *Eretmocerus mundus*. 2005-2009. V. Lo Verde, J. van Lenteren
- PE&RC new: Behaviour, anatomy and sensory physiology of chemosensillae in parasitoids. 2005-2009. S. Ruschioni, J. van Lenteren
- PE&RC new: Evaluation of natural enemies in augmentative biological control. 2005-2009. K. Bolckmans & W. Ravensberg, J. van Lenteren
- PE&RC 06068. Ethnobotanicals used for ectoparasites control in traditional livestock holdings 2004-2008. W. Wanzala, W. Takken
- PE&RC 06072. The effects of water management systems in traditional agriculture on Malaria Mosquitoes in Western Kenya. 2005-2009 . S. Imbahale, W. Takken, M. Dicke
- PE&RC Development and evaluation of entomopathogenic fungi for controlling malaria – a study to assess the efficacy of an entomopathogenic fungus for malaria intervention in rural villages of Tanzania. 2006-2010. M. Jumbe, W. Takken, B. Knols
- PE&RC 06077. Behavioural characteristics of the main malaria vector *Anopheles darlingi* in Suriname, and implications for vector control. 2006-2009. H. Hiwat, W. Takken & M. Dicke.
- PE&RC 31 05c. Linking direct and indirect plant defences in cultivated Brassicaceae to wild relatives. R. Gols & M. Dicke.
- PE&RC 31 05e. Reproductive biology and induced sterility as determinants for genetic control of mosquitoes with the sterile insect technique. M. Helinski, B.J.G. Knols & M. Dicke.
- PE&RC 06034. Effect of crop management on performance of endophytic *Fusarium* spp. in tissue culture banana against the banana weevil *Cosmopolites sordidus* (Germar) and nematodes in Uganda. D. Ochieno, A. van Huis & M. Dicke.
- PE&RC 32 03d. Linking interactions between above- and below-ground herbivores and the performance of parasitoids and hyperparasitoids. R. Soler, T.M. Bezemer, J.A. Harvey & L.E.M. Vet.
- PE&RC 07018. Disruption of malaria transmission by chemical manipulation of Anopheline olfactory responses. N. Verhulst, W. Takken & M. Dicke.
- PE&RC 06085. Cassava cropping and HIV/AIDS: assessing the contribution of experimental learning approach to crop protection, food security and family health in Domasi, Malawi. M. Yajima, A. van Huis & J. Jiggins.
- PE&RC 07002. Understanding success of biological pest control by predators based on their dispersal behaviour across habitat mosaics in ecological networks. B. Allema, & J.C. van Lenteren.
- PE&RC 07040. Establishment of the aphidophagous ladybird beetle *Harmonia axyridis* in The Netherlands: successful aphid control or ecological disaster? C.L. Raak-van den Berg, P.W. de Jong & J.C. van Lenteren.

- PE&RC 07045. Behavioural and ecological effects of fungal infection in adult malaria mosquitoes in Kenya 2007-2011. S.N. Ondiaka, R. Mukabana, B.G.J. Knols & M. Dicke
- PE&RC 07074. Biology and ecology of *Apanteles taragamae* Viereck, a larval parasitoid of *Maruca vitrata* Fabricius, a key pest of cowpea. 2007-2011. A.E. Dannon, A. van Huis & M. Dicke.
- PE&RC 07086. Ecogenomics of host plant use by a phytophagous insect. 2007-2011. K. Vermeer, P.W. de Jong & M. Dicke.
- PE&RC 07088. Entomopathogenic fungi for the control of malaria and dengue vectors. 2007-2011. T. Bukhari, B.G.J. Knols & W. Takken.
- PE&RC 07091. Optimizing the production of insects for human consumption and environmental impact. 2007-2011. A. Hoetmer, J.J.A. van Loon, A. van Huis.

REPRESENTATION IN EXTERNAL COMMITTEES

International:

- Consortium developing the SeaWaterGreenhouse, advisor crop protection (van Lenteren)
- ERA-MORE, European Network of Mobility Centres, Advisory Board (Vet)
- European Branch Society of Vector Ecology 2004-2006 (Takken, president)
- European Science Foundation (ESF), Science Advisory Board (Vet)
- European Science Foundation (ESF), Steering committee programme Volatile Organic Compounds in the Biosphere-Atmosphere System (VOC-BAS) (Dicke)
- European Food Safety Authority, Full member of Panel of Experts on Plant Health, (EFSA), Parma, Italy (van Lenteren)
- Expert Advisory Committee Canadian Network of Biocontrol Research (van Lenteren)
- Foundation Cradle2cradlePlanet, Board (Vet)
- Honorary Professor Beijing Normal University, China (van Lenteren)
- Honorary Professor University of Perugia, Italy (van Lenteren)
- International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC-IUBS) (2004-2008) (van Lenteren, President)
- International Congress of Entomology, Council (1998-2008) (Takken, secretary-treasurer)
- International Congress of Entomology, July 2008, Durban, South Africa, organisation of two symposia: (1) 'Insects and Society' (Dicke, van Huis), (2) 'Omics and Ecology and Evolution of Multitrophic Interactions' (Dicke, Vet)
- International Joint Workshop on PR Proteins and Induced Resistance Against Pathogens and Insects, Doorn, the Netherlands, May 2007 (Dicke, co-organiser)
- International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palearctic Regional Section (IOBC-WPRS), council member (van Lenteren)
- International Organization for Biological Control, IOBC, Steering Committee Working Group 'Induced Resistance' (Dicke)
- International Symposium 'Biogenic Volatile Organic Compounds: Sources and Fates in a Changing World', October 2007, Montpellier, France (Dicke, co-organiser)
- International Symposium 'Vegetative volatiles: molecular ecology and metabolomics' at Gordon Research Conference 'Floral & Vegetative volatiles', October 2007 (Dicke, co-organiser)
- Member Governing Council Interantional Centre for Insect Physiology and Ecology (ICIPE)(van Huis)
- OECD working group Regulation of Import and Release of Exotic Natural Enemies (van Lenteren)
- Panel of Experts on Environmental Management of Vectors (PEEM), WHO, Geneva (Takken)
- PhD examination committees at international university (van Lenteren, Vet)
- Scientific Program Committee Measuring Behavior 2008 (6th International Conference on Methods and Techniques in Behavioral Research) (Vet)
- Society for Vector Ecology 2006 (Takken, Scientific Board)
- Symposium on Chemical and Visual Ecology of Arthropods: From Genes to Pest Management, 15th to 18th September 2008, Windermere, United Kingdom (Organising Committee, van Loon, Dicke)
- Symposium 'Vegetative volatiles: molecular ecology, metabolomics and behavioural ecology' at Gordon Research Conference 'Floral & vegetative volatiles', Les Diablerets, Switzerland. October 7-12, 2007. (Dicke)
- Symposium "The integrative role of plant secondary metabolites in ecological systems", British Ecological Society: 2010 Symposium, 12-14 April 2010 – University of Sussex, UK (Organising Committee, Dicke)

- Visiting Professor, Institute of Zoology, Chinese Academy of Sciences, Beijing, China (van Loon)
- World Health Organization temporary advisor for 10-yr strategy TDR (Knols)
- X European Workshop on Insect Parasitoids, Sicily, Italy (organizer) (Vet)

National:

- Advisory Board for Nature Conservation, Prins Bernhard Cultuurfonds (Vet)
- Biological advisory board, Biologische Raad, KNAW (Vet)
- Board Foundation Royal Netherlands Institute for Sea Research (NIOZ) (Vet)
- Board IUCN Netherlands (Vet)
- Board NWO Darwin Centre for Biogeology (Vet)
- Board 'Landbouwexport fonds 1918', Wageningen (Dicke)
- Board Uyttenboogaart-Eliasen foundation (Dicke)
- Board Van Groenendael-Krijger fund (Dicke)
- Chair Netherlands Ecological Research Network (NERN) (Vet)
- Committee on Genetic Modification (COGEM), Ministry of Environment (Dicke)
- Committee 'Studium Generale' of Wageningen University, involved in extracurricular teaching (Dicke)
- Department of Plant Sciences, Wageningen University, advisory committees and working groups (Dicke)
- Dutch BioScience Forum (Vet)
- Earth and Life Sciences council of the Netherlands Organization for Scientific Research(ALW-NWO) (Dicke)
- Food-security Platform (professors dealing with development cooperation within Wageningen University) (van Huis)
- International Peer Review Committee, Alterra, WUR (Vet)
- Graduate School Production Ecology & Resource Conservation, Scientific Advisory Board, (Vet)
- Graduate School of Production Ecology & Resource Conservation, Educational Committee (Takken, chairman).
- Graduate School of Production Ecology & Resource Conservation (Scientific Committee, van Huis)
- Graduate school Production Ecology and Resource Conservation, Post graduate course "Biodiversity and Ecosystem Services in a Sustainable World" (van Huis, chairman organization committee)
- Hollandsche Maatschappij der Wetenschappen (Vet, van Lenteren)
- Institute of Biology Leiden University, Advisory Council (Vet)
- Jury Prins Bernhard Cultuurfonds, Prize for Nature Conservation (Vet)
- Library committee, Centre for Crop Protection, Wageningen University (de Jong)
- Linnaeus Symposium 2007, KNAW Amsterdam (co-organizer) (Vet)
- Measuring Behavior 2008, 6th International Conference on Methods and Techniques in Behavioral Research, Maastricht, The Netherlands. 26 - 29 August 2008. (Dicke, member of Scientific Program Committee).
- Member several PhD Examination committees (Dicke, van Loon, van Huis, van Lenteren, Takken, Vet)
- Ministry OCW on restructuring higher education (OCW-Profielcommissie N&T/N&G), Advisory Committee (Vet)
- National Committee of the International Year of Planet Earth (IYPE) (Vet)
- National Committee on the Prevention of Head Lice Infections, Ministry of Public Health (Takken)
- National Graduate School Experimental Plant Sciences, Scientific Advisory Board (Dicke).
- National Graduate School Experimental Plant Sciences. Education committee (Dicke, chairman).
- National Graduate School Experimental Plant Sciences. Scientific Committee (Dicke).

- National Graduate School Experimental Plant Sciences and European Science Foundation. Postgraduate Winterschool 'Ecology of Plant VOCs' (van Loon, Dicke).
- Natural History Museum Naturalis, Supervisory Board (Raad van Toezicht) (Vet).
- Netherlands Ecological Research Network (NERN) (Dicke, representative of Department of Plant Sciences)
- Netherlands Entomological Society (Dicke, vice-president)
- Netherlands Entomological Society, Section Experimental and Applied Entomology (SETE-NEV) (de Jong, secretary).
- Noorderlicht VPRO (popular scientific radio programme), Scientific Advisory Board (Vet)
- NWO/NGI Advisory Committee on systems biology research (Vet)
- Organizer Current Themes in Ecology Lecture Series (2/year) (Vet)
- Plantum Werkgroep Koolgewassen (van Loon)
- Royal Netherlands Academy of Arts and Sciences. (van Lenteren, Vet)
- Royal Netherlands Academy of Arts and Sciences, The Young Academy (Knols)
- Selection committee Wageningen University, TopTalent NWO grant proposals (Knols)
- Selection committee Wageningen University Dies Natalis Research Award 2008 (Knols)
- Scientific Advisory Board of exhibitions in Natural History Museum Naturalis (Vet)
- Symposium 'Gewasbescherming van opkomst tot oogst in gesloten productie', 5e Gewasbeschermingsmanifestatie, 22 May 2008, Wageningen, The Netherlands. (Dicke)
- Student (Plant Sciences, Wageningen University) recruitment activities (Knols)
- Supervisory Board National Centre for Science and Technology (NCWT, including Science Museum NEMO, Kennislink, Wetenweek) (Vet)
- Teylers Tweede Genootschap, Teylers Museum, Haarlem (Vet)
- User committee Resistance of white cabbage to the onion thrips, *Thrips tabaci*. Plant Research International (van Loon)
- Wageningen Plant Sciences Group-Wageningen UR-Expertise-unit Biointeractions and Health (Dicke, coordinator)
- Wageningen University, Biointeractions Laboratories within Department of Plant Sciences (Dicke, coordinator)

Journals:
- Annual Review of Entomology (Vet, editorial board)
- Biochemical Systematics and Ecology (Dicke, editorial board)
- British Ecological Society's Symposium Series (Vet, advisory editorial board)
- Chemoecology (Vet, associate editor)
- Ecological Entomology (Dicke, editorial board)
- Entomological Bulletin Guido Grandi, University of Bologna (van Lenteren, editorial board)
- Evolutionary Ecology (de Jong, editorial board)
- European Journal of Entomology (de Jong, editorial board)
- Insect Science (Dicke, editorial board)
- International Journal of Pest Management (van Lenteren, editorial board)
- International Journal of Tropical Insect Science (van Huis, editorial board)
- IOBC bulletins (van Lenteren, editor)
- IPM practitioner (van Lenteren, editorial board)
- Journal of Chemical Ecology (Dicke, editorial board)
- Journal of Ethology (Dicke, advisory board)
- Journal of Insect Behaviour (van Lenteren, Vet, editorial board)
- Malaria Journal (Knols, editorial board)

- Neotropical Entomology (van Lenteren, editorial board)
- Open Parasitology Journal (Knols, editorial board)
- Open Tropical Medicine Journal (Knols, editorial board)
- Plant Signaling and Behaviour (Dicke, editorial board)
- Terrestrial Arthropod Research (Knols, editorial board)

Photo: Marcel Dicke

PROJECTS FUNDED EXTERNALLY

- **2004-2007** Host-plant selection in *Helicoverpa* moths. Collaborative project with Institute of Zoology, Chinese Academy of Sciences, Beijing, China. Funded by Koninklijke Nederlandse Akademie van Wetenschappen, KNAW)
- **2001-2008** Genomics approach to integration of host plant insect resistance and biological control. Funded by Dutch and Chinese government.
- **2001-2007** Cross-talk between signal-transduction pathways in induced defence of Arabidopsis against microbial pathogens and herbivorous insects. Funded by NWO/ALW.
- **2001-2007** Development of a method for breeding of cucumber for improved attraction of biological control agents. Funded by Technology Foundation (STW).
- **2003-2007** Temperature distribution in shallow water bodies: Influence of abiotic factors on the population dynamics of immature stages of African malaria vectors. Funded by WOTRO.
- **2004-2007** Molecular characterisation of mechanisms of *Solanum* resistance to *Myzus persicae* - Impact on PLRV transmission. Funded by Alβan-EU.
- **2004-2007** Evolutionary transition from solitary to gregarious development in parasitoid wasps. Funded by NSF. (collaboration between Wageningen University, University of Minnesota, Norht Dakota State University and University of Illinois).
- **2004-2008** Linking variation in plant defence to higher level biodiversity. Experimental Plant Sciences, Strategic Funds. (collaboration between Entomology, NIOO and Plant Research International).
- **2004-2008** Spatio-temporal modelling of infochemicals in a food-web context. Funded by NWO-ALW (collaboration with Mathematical and Statistical Methods Group)
- **2004-2008** Ethnobotanicals for the control of *Ripicephalus appendiculatus*, the vector of East Coast Fever in East Africa. Funded by Wageningen University, IFS and ICIPE.
- **2004-2008** Effect of agro-ecological conditions and banana crop management of efficacy and persistance of Beauveria bassiana for control of the banana weevil in Uganda. Funded by Wageningen University, Rockefeller foundation and IITA.
- **2004-2008** Assessing the contribution of Farmer Field School approach to the management of cassava, soil and family health and its role in food security in Malawi. Funded by JICA.
- **2004-2008** Crop protection perspectives in Kazakhstan: shifting interfaces between farmer practice and agricultural research. Funded by WUR and Govt. of Kazakhstan.
- **2004-2009** A molecular genetic approach to chemical ecology and community ecology. Funded by NWO-VICI.
- **2004-2009** Behavioural and ecological determinants of gene flow in African malaria vectors. Funded by NWO-VIDI.
- **2004-2009** Ecological and physiological functions of biogenic isoprenoids and their impact on the environment (ISONET). Funded by EU.
- **2005-2006** Behaviour, anatomy and sensory physiology of chemosensillae in parasitoids. (Financed by Univ Ancona)
- **2005-2007** Evaluation of natural enemies in augmentative biological control. (Financed by Koppert BV)
- **2005-2008** Behaviour and elimination of supernumerary parasitoid larvae in *Eretmocerus mundus*. (Financed by Univ Palermo)
- **2005-2009** Phenotypic plasticity of taste in insects. Funded by the Royal Dutch Academy of Arts and Sciences (KNAW), in collaboration with the Chinese Academy of Sciences, Institute of Zoology, Beijing, China.

- **2005-2009** Effect of crop management on performance of endophytic *Fusarium* spp. in tissue culture banana against the banana weevil *Cosmopolites sordidus* (Germar) and nematodes in Uganda (sandwich scholarship).
- **2005-2009** Assessing the contribution of Farmer Field School approach to the management of cassava, soil, and family health and its role in food security in Malawi". (funded by JICA)
- **2005-2009** Crop Protection Perspectives in Kazakhstan: Shifting Interfaces between Farmer Practice and Agricultural Research (funded by WUR and Kazakhstan)
- **2006-2007** Naturally healthy from day to day: a national interactive website for monitoring, forecasting, managing and communicating health risks from nature in space and time. (funded by RGI, the Netherlands – Space for Geoinformation)
- **2006-2008** Innovative biological control of malaria mosquitoes using fungi.
- **2006-2007** Effect of biodiversity in natural ecosystems on Borrelia spp. (causative agents of Lyme disease) population dynamics in ticks (*Ixodes ricinus*). (funded by WUR-PSG)
- **2006-2009** Harmonization of regulation regarding risk assessment of exotic organisms. (Financed by EU)
- **2006-2009** Insect collections for identification of pests. (Financed by Ministry of Agriculture).
- **2006-2010** Development and evaluation of entomopathogenic fungi for controlling malaria – a study to assess the efficacy of an entomopathogenic fungus for malaria intervention in rural villages of Tanzania.(Funded by Dioraphte).
- **2006-2010** Chemical communication: Hitch-hiking parasitic wasps spy on butterfly anti-aphrodisiacs (Funded by NWO-ALW)
- **2007-2010** Mosquito vectors of disease: spatial biodiversity, drivers of change, and risk. Principle Investigator: Willem Takken in collaboration with the Tropical Institute, Antwerp (Dr. W. van Bortel). Funding: Science for a Sustainable Development (SSD), Federal Government of Belgium.
- **2007-2008** Overwintering behaviour of adult *Culicoides* and the impact of insecticides on livestock farms in the Netherlands. Principle investigator: (Funded by Ministry of Agriculture)
- **2007-2009** Precompetitive Programme on Taxonomy of Insects (Funded by Ministry of Agriculture)
- **2007-2010** Attract and kill method to combat the red poultry mite (Funded by Ministry of Agriculture and Productschap voor Vee, Vlees en Eieren)
- **2007-2010** Chemical ecology of egg parasitoids (Funded by DFG).
- **2007-2011** Development of an ecological method to evaluate the effects of GM crucifer crops, altered in direct and indirect plant resistance traits, on non-target organisms in relation to baseline information. (Funded by NWO-ALW Thematic Program Environmental Risk Assessment of Genetically Modified Organisms).
- **2007-2011** Biology and ecology of *Apanteles taragamae* Viereck, a larval parasitoid of *Maruca vitrata* Fabricius, a key pest of cowpea. (Funded by NUFFIC)
- **2007-2011** PE&RC 07088. Entomopathogenic fungi for the control of malaria and dengue vectors. (Funded by NUFFIC)
- **2007-2012** INterSECT: Development of innovative methods for selecting and engineering natural resistance to thrips in ornamental and vegetable crops (Funded by Technological Top Institute Green Genetics)
- **2007-2012** Resistance against whitefly in tomato (Funded by Technological Top Institute Green Genetics)

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