WAGENINGEN UNIVERSITY
WAGENINGEN UR

ANNUAL REPORT 2000-2001

LABORATORY OF ENTOMOLOGY

PERSONNEL PER 1 JANUARY 2003

Professors:
Prof. Dr. Marcel Dicke
Prof. Dr. Joop van Lenteren
Prof. Dr. Louis M. Schoonhoven (emeritus)
Prof. Dr. Louise E.M. Vet

Personnel:
Aggelen, Frans K.M. van
Almeida MSc, Raoul P. de (EMBRAPA)
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Ayenor MSc, G.K.
Bleeker, Ir. Maartje (NWO)
Boer, Ir. Jetske G. de (NWO)
Bukovinszky MSc, Tibor (NWO)
Boot, Dr. Ir. Willem J. (WOTRO)
Burgio MSc, G.
Boudewijn, Marthy
Calis, Dr. Johan (WOTRO)
Charleston MSc, Deidre S. (IFS)
Dicke, Prof. Dr. Marcel
Docters van Leeuwen, Ir. Buul
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Gidding, André
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Gols, Ing. Rieta
Gonzalez MSc, Gladys (Gov. Panama)
Hess, Drs. Linde (NWO)
Huigens, Ir. Ties (NWO)
Huis, Dr.Ir. Arnold van
IJkhout, Bart
Jeong MSc, Gil Sang
Jong, Dr. Peter W. de
Jongema, Yde
Kappers, Dr.Ir. Iris F. (STW)
Kindt, Drs. Frodo (STW)
Knols, Dr. B.G.J.
Koenraadt, Ir. Sander (WOTRO)
Koopman, Leo
Lenteren, Prof. Dr. Joop C. van
Loomans, Ir. Antoon J.M. (EU)
Loon, Dr.Ir. Joop J.A. van
Luckerhoff, Ing. Ludo (STW)
Masanza MSc, Michael (IITA)
Meerman, Ir. Frans
Meijerink, Sabine M.
Nederlof, Ir. S.
Niyibigira MSc, Emmanuel I. (WOTRO)
Oosten, Drs. Vivian van (NWO)
Pesch, Gerard J.K.
Poitevin, Ir. Olivier (STW)
Potting, Dr. Roel P.J.
Qiu, MSc., Yu Tong (STW)
Roseboom, Dick J.
Scholte, Ir. Ernst Jan (WOTRO)
Schoonhoven (emeritus), Prof. Dr. Louis M.
Schütte, Ir. Conny
Silva, Dr. Isabel M.M.S. (STW)
Sinzogan, MSc, Antonio
Smallegange, Ir. Renate (STW)
Smid, Dr. Hans M.
Spitzen, Ing. Jeroen
Szendrei MSc, Zsofia
Takken, Dr.Ir. Willem
Tigges, Wouter
Tinzaara, MSc, W. (IITA)
Tjallingii, Dr. Freddy
Tomassini MSc, M.G.
Trefas MSc, Hajnalka
Twigt, Wilma
Verbaarschot, Ing. Patrick
Vet, Prof. Dr. Louise E.M.
Vugt, Ir. Joke van (NWO)
Wäckers, Dr. F. (KNAW)
Winkler, Ir. Karin (Bosch Foundation)
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ANNUAL REPORT LABORATORY OF ENTOMOLOGY 2001 & 2002

CONTENTS

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Cover: the cover design is based on the cover of the PhD thesis by Dr. Isabel Silva

FOREWORD

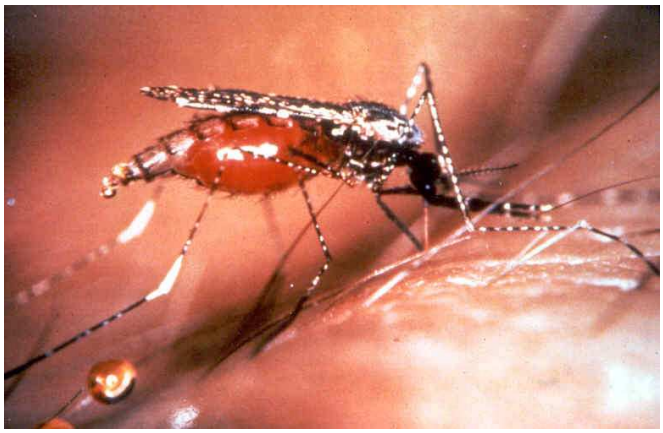
This annual report covers two years, i.e. 2001 and 2002. In these years several new permanent scientific and technical staff have joined the Laboratory with new impetus to our research programme. In addition, our teaching programme has been modified as a result of the changes towards the Bachelor-Master programme within Wageningen University.

The research of the laboratory of Entomology has been updated and is now centered around three themes: (1) chemical and molecular ecology, (2) population and behavioural ecology and (3) functional biodiversity and agroecology.

This annual report is much reduced in size compared to previous annual reports. This does not mean that the activities of the Laboratory of Entomology have been drastically reduced. Rather we are shifting our communication to our website where you can find more details on our teaching and research programmes, on recent PhD theses, on our social activities and much more. See www.dpw.wageningen-ur.nl/ento/english/index.htm

As of January 1st 2003 Joop van Lenteren has stepped down as head of the Laboratory of Entomology after leading the group for almost 20 years. Joop will continue to work within the Laboratory of Entomology and will concentrate on supervision of PhD students, on research in the field of functional biodiversity and on regulation of importation of exotic organisms. The undersigned has been appointed as the new head of the Laboratory of Entomology as of January 1st 2003. The Laboratory of Entomology has flourished during the past 20 years and we will work hard and with inspiration to continue doing so.

Marcel Dicke



ACTIVITIES

GENERAL

In 2001 and 2002 the new structure of Wageningen University and Researchcentre (Wageningen UR) has been further developed. Wageningen UR is a close collaboration between Wageningen University and the DLO Foundation, which are distinct legal entities.
The Laboratory of Entomology participates within the Department of Plant Sciences of Wageningen University, together with 15 other groups such as the laboratories of Phytopathology, Nematology, Virology, Genetics, Molecular Biology, Crop and Weed Science and others (www.wur.nl/uk/research).
Within Wageningen UR, the Department of Plant Sciences is closely collaborating with Plant Research International (DLO) and the Applied Plant Research institutes (DLO) in Aalsmeer, Boskoop, Horst, Lisse, Lelystad, Naaldwijk and Randwijk. The laboratory of Entomology collaborates with these groups in the area of Bio-interactions and Health.

In February of 2002, our colleague Peter Mols, who worked on population dynamics of insects in fruit orchards died while on his way to work. He worked at Wageningen University for more than 25 years. Peter had suffered severe health problems in the past years, he was recovering remarkably well and was to make an early retirement in the spring of 2003. He had many plans for research after his retirement, but unfortunately has not been able to realize these.

Two permanent staff members made an early retirement as of January 1st, 2003: Joop van Lenteren (see below) and Freddy Tjallingii. Both will continue to supervise PhD students and do research within the Laboratory of Entomology. The following colleagues have left in 2001 and 2002: Bertha Koopmanschap-Memelink, Herman Dijkman, Richard Stouthamer, Fredy Vaal, Piet Huisman, Ineke Kok and Marieke Bosman.
New colleagues in the Laboratory of Entomology are: Patrick Verbaarschot, Rieta Gols, Jeroen Spitzen, Peter de Jong, Sabine Meijerink, Wilma Twigt, Marthy Boudewijn, Nina Fatouros, Linde Hess, Bart IJkhout, Iris Kappers, Ludo Lückerhoff, Roel Potting and Wouter Tigges.

Our research flourished in 2001 and 2002. We have organized two international symposia in Wageningen, i.e. the 1st IOBC Conference on *Induced resistance in plants against insects and diseases* in April 2001 and the Frontis workshop on *Ecology of transgenic mosquitoes* in June 2002. Willem Takken and Bart Knols published a paper in *Science* on the ecology of transgenic mosquitoes. Joop van Lenteren was elected in 2001 as member of the Royal Dutch Academy of Sciences and received an honorary professorship at the University of Perugia, Italy. Marcel Dicke obtained the prestigious VICI-grant from the Dutch Organisation for Scientific Research (NWO) to carry out research in the field of ecogenomics. A large number of scientific publications appeared in internationally peer-reviewed journals.

Joop van Lenteren has finished editing a book on Quality Control and Production of Biological Control Agents: Theory and Testing Procedures, which is meant for all persons involved in rearing of insects. Marcel Dicke has edited a special issue of the journal Biochemical Systematics and Ecology on communication between plants, entitled "Chemical information transfer between damaged and undamaged plants".

The innovation of the teaching programme is almost complete. It is encouraging to experience that the students are enthusiastic about the new courses. The number of students that participated in our courses was much larger than in the older courses during the past years. In the years 2001 and 2002, six and seven PhD students, respectively, successfully defended their theses.

THE LABORATORY OF ENTOMOLOGY UNDER JOOP VAN LENTEREN: 1983-2002.

As of January 1st, 2003 Joop van Lenteren stepped down as head of the Laboratory of Entomology. He had taken over the chair of Entomology from Professor Jan de Wilde in August 1983. Under Joop van Lenteren the laboratory of Entomology has flourished. In total 71 PhD students have defended their PhD thesis in the period 1983-2002 (Fig 1) and a large number of papers have been published (Fig 2).

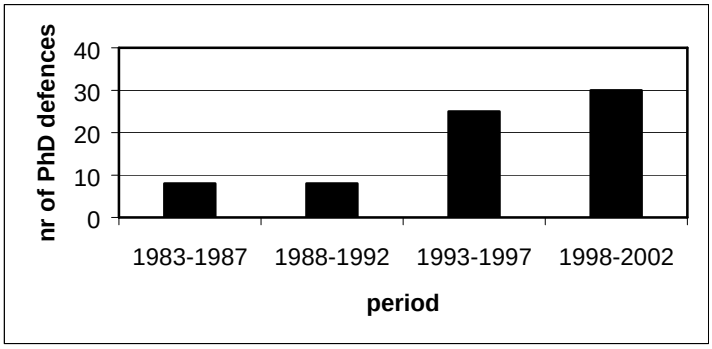


Figure 1: The number of PhD defences in the Laboratory of Entomology in the period 1983-2002. The total number of PhD defences in the period is 71.

Van Lenteren had specific plans with the department and arranged for an adequate connection of insect physiology and insect ecology through the intensive collaboration with Louis Schoonhoven. This was the outcome of the vision that excellent entomological research should integrate a mechanistic with a functional approach. This has proven to be very true. The research has bloomed and there were many highlights including 3 papers in Nature and 1 in Science.

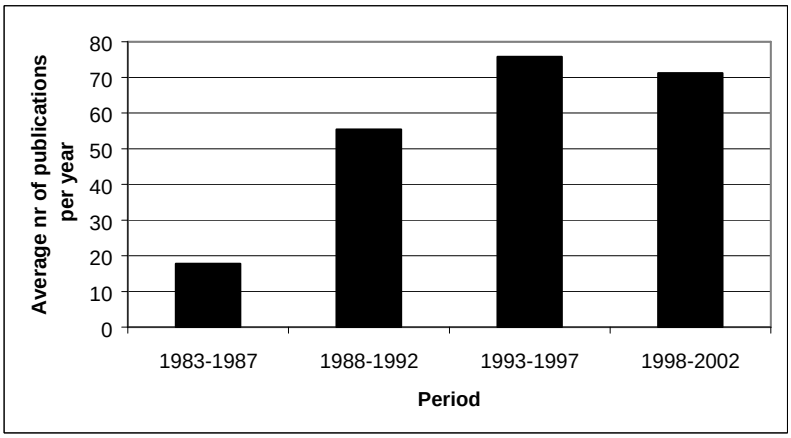


Figure 2: The average number of publications in peer reviewed journals and books by members of the Laboratory of Entomology in the period 1983-2002. The total number of these refereed papers over 1983-2002 is 1131.

Although these achievements are the result of the work by all members of the group, Joop certainly has had an important role. An ant colony depends on the hard work of all members, but without a queen it would be an unorganized group that would soon disintegrate. The queen sends out messages to organize the state. In a similar way, Joop van Lenteren has devoted a lot of energy and time to the organization of the laboratory of Entomology and this was very important for the development of the group. Under his guidance the members of the laboratory of Entomology were free to develop as responsible and independent thinkers even though Joop developed the contours of the group at so many decisive moments. This has made working in the laboratory of Entomology very enjoyable because of the good atmosphere within the group.

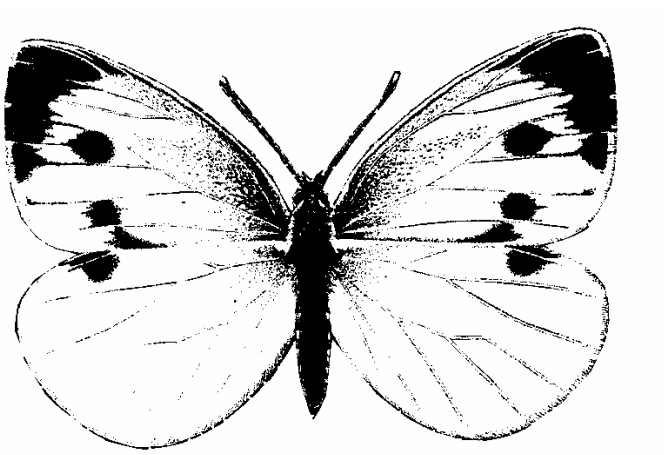
It should be stressed that Joop van Lenteren will not leave the Laboratory of Entomology. We are happy that he will continue to contribute to the activities of the Laboratory's projects and he will represent the Laboratory of Entomology in national and international organisations. The foci of his activities will be the supervision of PhD students, research on functional biodiversity and durable agriculture and legislation on the importation of exotic arthropods for biological control of insects pests. In addition he will be be associated as a guest professor to the University of Perugia.

OBITUARY PETER J.M. MOLS

Peter Mols died during his daily bike ride from his home to the laboratory as the result of heart failure on 7 February 2002. Peter was struggling with serious heart problems already for several years, but he enjoyed his work so much that he still spent most of his time at the laboratory or in the field studying non-chemical control of apple pests. After his plant protection study, Peter worked initially with the plant protection service. He then started with a PhD project, which resulted in his thesis "Walking to survive: searching, feeding and egg production of the carabid beetle "*Pterostichus coerulescens* L." After finishing his PhD research, he was appointed as junior researcher at the Laboratory of Entomology of Wageningen University. His task was to give courses in IPM, to supervise students working in the IPM orchard of the department, and to study biological control of orchard pests. At that time, IPM experienced a very strong development in Holland and developments in apple orchards were trend setting for most of the work in Europe. Peter and many of his students strongly contributed to the knowledge of both pests and natural enemies in apple orchards. Peter's own research concentrated on development of models that predicted occurrence and population dynamics of orchard pests, and on the relationship between apple aphids and the whole complex of their natural enemies.

He initiated many Dutch and international students enthusiastically in modeling. Peter's teaching consisted of courses in applied entomology and IPM, and he also often contributed to courses of the International Agricultural Centre. One of his major contributions to teaching was the development of an integrated course on sampling as basis for control of pests and diseases, which he did together with colleagues from the department of Phytopathology. Another well-appreciated activity was his devoted organization and supervision of many national and international crop protection excursions.

Peter has worked for 20 years at the Laboratory of Entomology. He will be remembered as an enthusiastic, broadly oriented and very helpful colleague.



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 Animals Sciences, Biological Production Sciences, Molecular Sciences and Environmental Sciences. The laboratory of Entomology is involved in the following courses:

- Analysis and Prevention of Health Risks in Tropical Countries
- Bee Science
- Biology and Control of Pests and Diseases I
- Biology and Control of Pests and Diseases II
- Biosystematics and Biodiversity
- Ecological Aspects of Bio-interactions
- Ecology
- Ecophysiology
- Evolutionary 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 Conservations (PE&RC:http://www.dpw.wageningen-ur.nl/PEenRC).

In the academic year **2000/2001** a total of 27 students finished their MSc-thesis under the supervision of the staff of the Labatory of Entomology. In addition, 1 student completed an internship at a national or international institution.

In the academic year **2001/2002** a total of 28 students finished their MSc-thesis under the supervision of the staff of the Labatory of Entomology. In addition, 12 students completed an internship at a national or international institution.

STUDENT THESES 2001

- Busstra, C., 01.19. Population expansion of *Diabrotica virgifera* (Chrysomelidae: Coleoptera) in Europe: a modelling approach.
- Damme, P. van, 01.16. Can jasmonic acid application to lima bean plants improve prey findingof *Phytoseiulus persimilis*.
- Djomamou, B.N., 01.02. Using *Crotalaria retusa* and *Uscana lariophaga* for the integrated control of *Callosobruches maculatus* on cowpea.

- Duuren, J. van, 01.27. History of Pierce's disease, a lethal plant disease and the approach of genetic engineering as a solution
- Ghimire, M.N., 01.01. Spatial dispersal of *Uscana lariophaga* in stored cowpea in the presence of its host, *Callosobruchus maculatus*
- Höfte, M., 01.22. Response of the predatory mite Phytoseiulus persimilis to volatiles in mixed-cropping systems.
- Ibrahim, O.A.E., 01.03. Management of diamondback moth *Plutella xylostella linnaeus* using entomopathogenic fungi.
- Klunder, M., 01.08. Coping with negative experiences in a social and non-social context in Great Tits Parus major.
- Lommers, E., Verhulst, N., 01.21. Life expectancy of *Encarsia* species (*Hymenoptera, Aphelinidae*) in their natural habitat.
- Mazerand, P., 01.18. Reaction of British growers to the organophosphorus pesticide review. A focus on cabbage root fly control.
- Mazerand, P., 01.28. A focus on cabbage root fly control.
- Meulengraaf, B. van de, 01.26. Mechanism behing horizontal transmission of Wolbachia & influcence of Wolbachia on development of *T.* Kaykai inside the host egg.
- Oosten, H. van, 01.25. On life-history trait differences between the a-sexual and sexual reproducing parasitoid wasp.
- Paaijmans, K., 01.15. The ecology of larval *Anopheline* mosquitoes in the highlands of Kenya.
- Pijpe, J.,01.05. Protandry in bicyclus anynana.
- Pumarino, L., 01.07. Are herbivore-induced volatiles from Arabidopsis thaliana herbivore specific. Foraging behvior of *Cotesia rubecula* and *Phytoseiulus persimilis.*
- Ribeiro, M.M.S., 01.12. Experience and learning in predatory mites.
- Roosjen, M., 01.13. Flight behaviour of Cotesia rubecula in response to volatiles induced by host *Pieris rapae* and nonhost herbivores with different feeding patterns.
- Rijswijk, M. van, 01.11. DNA typing of otter spraints from a natural population methodology and ecology.
- Salverda, M., 01.17. Mode of actin of the PSR-chromosome of *Trichogramma kaykai.*
- Schenk, Roodbergen, Pijpe, Meulengraaf, v.d., 01.20. Fieldwork on Trichogramma and their sex-ratio distorters in the Mojave desert, (CA, USA) 2001. Why do Wolbachia infected females mate? Heterosis, a possible explanation.
- Wal, van der, 01.10. Wolbachia influence on superparasitization propensity of *Trichogramma kaykai* and the population diversity of Wolbachia.
- Wassenberg, J., 01.14. Presence of other bees as landing guide: the role of local enhancement in the flower choice of stingless bees.
- Wijnans, L., 01.24. Malaria in Nederland angsbeleid of toekomstbeeld.
- Zee, B. van der, 01.06. The VUM neuron and the difference in learning ability between the two closely related parasitoid wasp species *Cotesia glomerata* and *Cotesia rubecula.*

STUDENT THESES 2002

- Aveskamp, M., 02.40. A novel bacterial disease in the predatory mite *Phytoseiulus persimlis* dispersal behaviour and disease transmission by infected adult females.
- Belt, S., 02.14. Royal Van Zanten Uganda ltd. Growing practice and disease control.
- Berg, L. van den, 02.15. Wittevliegdichtheden en verdelingen in Costa Rica, de natuurlijke omgeving van *Encarcia formosa.*

- Berg. L. van den, 02.29. Gedrag en ontwikkeling van de Diamond moth (*Plutella xylostella)* op waslaagmutanten van Arabidopsis thaliana.
- Brouwer, H., 02.18. Memory structures of the parasitoid wasp Cotesia glomerata.
- Brouwer, H., 02.34. Fieldwork on Trichogramma and it's sex ratio distorters in the Mojave desert (Ca, USA) 2002.
- Cazé, A., 02.16. Bruchids and their natural enemies in Cowpea (Vigna unguiculata W.) and other leguminous plant species and their interactions.
- Clough, Y., 02.06. Foraging behaviour and searching efficiency of parasitoids in a polyculture: comparison of a generalist and a specialist
- Estay, T., 02.05. Dispersal and movement of *Diadegma semiclausum* parasitoid of *Plutella xylostella* in a simple and diverse system.
- Fischer, E.A.J., 02.20. Ovioposition-site selection of Anopheles gambiae giles s.s.
- Gils, H. van, 02.10. The influence of soil texture and pf on oviposition and egg hatch of the desert locust (Schistocerca gregaria).
- Helinski, M., 02.28. Phenology of Ixodes ricinus and prevalence of Boerrelia spp. In two study sites in the Netherlands in late winter and early spring.
- Hulskes, A., 02.32. The origin of the paternal sex ratio chromosome in Trichogramma kaykai.
- Larraz, V., 02.02. Comparison of flowering herbs with respect to their nectar suitability for the herbivore *Pieris rapea* and its parasitoid *Cotesia glomerata.*
- Lommen, S., 02.31. Induction mechnisms of defences in Gossypium herbaceum.
- Lommers, E., 02.17. Effect van verschillende daglengtes op Leptomastix dactylopii en Leptomastidea abnormis.
- Munneke, M., 02.23. Orientation behaviour of the predatory bug *Podisus maculiventris* in response to different odour sources.
- Musharaf, M., 02.07. Geographic information systems for mapping malaria risks in Western Kenya.
- Nguyen Quoc, B., 02.12 Potential of predatory wasps as control agent of the cotton leaf roller *Sylepta derogata.*
- Paaijmans, K. , 02.35. Larval population dynamics of *An. Maculipennis* s.l. in three different geographical locations in the Netherlands.
- Paaijmans, K., 02.13. Kinship studies among larvae of *Anopheles arabiensis* and *Anopheles gambiae* s.s. in Miwani, Western Kenya, using microsatelite loci.
- Poelman, E., 02.37. Reproductive parasitism and food provisioning behaviour in the Amazonian poison frog *Dendrobates verntrimaculatus* (Shreve 1935)
- Pruijssers, A., 02.08. Cytogenetic and Molecular analysis of the PSR chromosome in *Tr. kaykai.*
- Schenk, M.F., 02.19. The level of sib-mating in a field population of Trichogramma kaykai.
- Sinzogan, A., 02.01. Oviposition – deterrent and toxic effects of various botanicals on two parasitoids (*Dinarmus basalis*) (Rond.) and Uscana lariophaga (Steffan)). Of *Callosobruchus maculatus* Fab. Infesting cowpea (Vigan unguiculata W.).
- Snoeren, T., 02.36, Learning to discriminate prey and non-prey induced plant voloatiles by the predatory mite Phytoseiulus persimilis.
- Stone, C., 02.38. Oviposition behaviour and larval development of the Afrotropical malaria vector *Anopheles gambiae Giles* in different larval habitats.
- Termaat, T. Het foerageergedrag van de roofmijt Phytoseiulus persimilis in een omgeving met meerdere plantherbivoorcomplexen.
- Tolenbayev, K., 02.04. Effect of food plant quality on fitness of the desert locust (Schistocerca gregaria).
- Valdivia, L., 02-03. Comparison of flowering herbs with respect to their nectar suitability for the herbivore *Plutella xylostella* and its parasitoid *Diadegma semiclausum.*

- Wijnen, J., 02.22. Age related decrease in transmission of parthenogenesis inducing Wolbachia in Trichogramma deion.
- Wijnans, L., 02.24. Malaria in Sri Lanka
- Wijnen, J., 02.26. Host preference in *Aphytis melinus.*
- Wubbels, T., 02.27. The influence of nitrogen fertillisation on the development and reproduction of Sysaphis plantaginea (Passerini) on apple trees.
- Wubs, M., 02.30. Desert locust population dynamics.

PHD THESES 2001

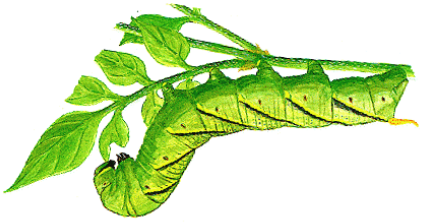
A total of 6 Phd theses were completed and succesfully defended:

- Boff, I.C.The entomopathogenic nematode *Heterorhabditis megidis:* host searching behaviour, infectivity and reproduction. Promotor: Prof. J.C. van Lenteren; Co- Promotor Dr. P.H. Smits
- Vos, M. Foraging under incomplete information: Parasitoid behavior and community dynamics. Promotors Prof. Dr. L.E.M. Vet, Prof. Dr. J.C. van Lenteren; Co-promotor Dr. L. Hemerik
- Calis, J.N.M. Parasite-host interactions between the *Varroa* mite and the honey-bee. Promotors Prof. Dr. J.C. van Lenteren; Prof. Dr. M.W. Sabelis
- Meekes, E. T.M. Entomopathogenic funig against whiteflies. Promotor Prof. Dr. J.C. van Lenteren; Co-Promotor Dr. Ir. J.J. Fransen
- Wertheim, B. Ecology of *Drosophila* aggregation pheromone. Promotors Prof. Dr. L.E.M. Vet, Prof. Dr. M. Dicke, Prof. J.C. van Lenteren; Co-Promotor Dr. L. Hemerik
- De Vis, R.M.J. Biological control of whitefly on greenhouse tomato in Columbia: *Encarsia formosa* or *Amitus fuscipennis?* Promotor Prof. Dr. J.C. van Lenteren; Co-Promotor Dr. Ir. J.J. Fransen

PHD THESES 2002

A total of 7 Phd theses were completed and succesfully defended in 2002:

- Gnanvossou, D. Infochemical use by predatory mites of the cassava green mite in a Multitrophic context. Promotor Prof. Dr. M. Dicke; Co-Promotor Dr. R. Hanna
- Boeke, S.J. Traditional African plant products to protect stored cowpeas against Insect damage; The battle against the beetle. Promotor Prof. Dr. M. Dicke; Co-Promotor Dr. Ir. J.J.A. van Loon
- Poecke, R.M.P. Indirect defence of *Arabidopsis* against herbivorous insects. Combining parasitoid behaviour and chemical analyes with a molecular genetic approach. Promotor Prof. Dr. M. Dicke
- Mukabana, W.R. Differential attractiveness of humans to the African malaria vector *Anopheles gambiae* Giles. Effects of host characteristics and parasite infection. Promotor Prof. Dr. J.C. van Lenteren; Co-Promotors Dr. Ir. W. Takken, Dr. Ir. B.G.J. Knols
- Stolk, C. Spatial and behavioural aspects of foraging by *Uscana lariophaga,* Egg parasitoid of *Callosobruchus maculatus,* in stored cowpea. Promotor Prof. Dr. J.C. van Lenteren; Co-Promotors Dr. Ir. A. van Huis, Dr. Ir. W. van der Werf
- Burger, J. How to behave? Evol. of host-handling behaviour in the whitefly Parasitoid *Encarsia formosa.* Promotors Prof. Dr. J.C. van Lenteren, Prof. Dr. L.E.M. Vet; Co-Promotor Dr. L. Hemerik
- H.V. Pates. Zoophilic and anthropophilic behaviour in the Anopheles gambiae complex. Promotors: Prof. Dr. C. Curtis and Dr. W. Takken. London : London School of Hygiene and Tropical Medicine.



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) and Experimental Plant Sciences (EPS - http://www.graduateschool-eps.info/).

Progress in the research programmes is presented below:

Chemical and sensory ecology

J.J.A. van Loon, H. Smid, M.A.K. Bleeker, S. Boeke, A.E. Eben, W. van Giessen, L. Hess, Y.-T. Qiu, J.L.M. Steidle

Plants that are subject to feeding damage by herbivorous insects respond by modifying their production of volatiles. The blend of volatiles that is released attracts natural enemies of the herbivores and this volatile production thus acts as an indirect defence mechanism of the plant. In response to feeding injury, *Brassica oleracea* plants release ca. 80 volatile compounds. Odour preferences of the two closely related braconid wasp species (*Cotesia glomerata* and *C. rubecula* (Braconidae: Hymenoptera)) have been extensively documented at our laboratory in the group of Louise Vet. To answer the question of which of these compounds are used by endoparasitoid wasps (*Cotesia* spp.) during their search for herbivorous host caterpillars of cabbage white butterfly larvae (*Pieris* spp.), we undertook a coupled electrophysiology – gas chromatography (GC) – mass spectrometry (MS) study. Twenty volatiles evoked consistent electroantennogram (EAG) reactions, indicating that the olfactory system of the wasps detected these compounds. We compared the responses of two closely related wasp species which differ in their innate preference for odour blends released by different *Brassica-Pieris* host-plant herbivore complexes. A remarkable similarity in olfactory response profiles of the antennal receptor population of these two wasp species was established, suggesting that differences in central nervous processing rather than qualitative differences in the peripheral receptors of the olfactory system explain the differences in odour-based orientation behaviour. To understand the neuronal basis of the clear-cut difference in odour preference a

three-dimensional map of the glomeruli of the olfactory lobe of both wasp species was constructed. Glomeruli were stained by retrograde axon tracing of all axons in the antennal nerve and observed by confocal laser scanning microscopy. The combined use of 2D images and 3D surface models of the antennal lobes enabled the identification of a set of corresponding glomeruli in both wasp species. This approach will in the near future be combined with immuno-cytochemical - and gene-expression studies in attempts to pin down which neurobiological differences between both species underlie the differences in olfaction-based behaviour.
The two *Cotesia* species consistently differ in the degree of plasticity of their searching behaviour. *Cotesia glomerata* needs only one oviposition experience to establish associative learning, whereas in our dual-choice flight bioassays *C. rubecula* was not found to change its innate preference for a plant-host complex offered as an odour source. We recently adopted a sensitisation-controlled no-choice flight bioassay which demonstrated that *C. rubecula* also shows associative learning which, however, shows significantly shorter memory retention (1 day) as compared to *C. glomerata* (5 days).
The project aimed at identifying plant material indigenous to West-Africa with control potential against the seed beetle *Callosobruchus maculatus,* the most important pest insect in stored cowpea *Vigna unguiculata*, led to the successful identification of a number of promising plant species. Side effects on egg and larval parasitoids of the beetle were demonstrated that constrain the use of some of the plant species that directly affect the development or behaviour of *C. maculatus*. This project was finished in November 2002 with the publication of the PhD thesis of S. Boeke. Farmers in Benin have already applied results from this project.

Ecology, evolution and genetics of interactions between phytophagous insects, their host plants, and their enemies.
P.W. de Jong, P. Verbaarschot

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. Peter de Jong, who joined the laboratory of Entomology in December 2001, initiated new research to study such interactions, including at the molecular level. The work builds on his earlier work, carried out with Dr. Jens Kvist Nielsen in Copenhagen, and Prof. Paul Brakefield and Prof. Ed van der Meijden at the University of Leiden, with all of whom close collaboration is continued. The research programme is closely tied to the three major foci of interest of the laboratory of Entomology, especially the first two: a) chemical- and molecular ecology; b) behavioural- and population ecology, and c) functional biodiversity and agroecology. The project focuses on the interaction between a flea beetle, its (natural) host plants, and its enemies. The chrysomelid flea beetle *Phyllotreta nemorum* lives on a limited number of Crucifers. The larvae are leaf miners, implying an intimate relation with the host plants, including (chemical) host-plant defences. *Barbarea vulgaris* is an atypical host plant of this beetle: one chemically distinguishable form of this plant is unsuitable as host plant for the majority of *P. nemorum*. The adults do not eat from this plant, and the larvae die within three days when put on leaves of the plant. However, populations have been discovered that use this plant as their natural host. These beetles are apparently 'resistant' to the defences of *Barbarea*. We have found that this resistance is genetic, and involves genes with a major phenotypic effect. Some of these genes appear to be located on the sex chromosomes, whereas others seem to be autosomally inherited. The beetles are polymorphic for the presence of these genes; when collected on *Barbarea* in the field, all beetles have resistance genes, but on other host plants a major proportion of the beetles does not contain resistance genes. These observations raise a number of fundamental questions: 1) why are not all beetles resistant to *Barbarea* defence?; 2) what ecological and/or genetic factors limit the spread of resistance genes?; 3) how many loci are involved in the resistance, what is their inheritance, and if there is more than one locus involved, did they originate as independent mutations? To answer these and related questions, we attempt

to integrate evidence from ecological observations, (population) genetic studies and fitness-measurements, using a variety of experimental approaches, including field work and DNA techniques.
In 2002, a review was published that proposed a hypothesis to explain the present geographical distribution of resistance against *Barbarea*-defences in *P. nemorum*: the existence of coadapted gene complexes. This hypothesis assumes a certain degree of genetic structure in the flea beetle populations, which was studied in 2002 by means of allozyme-markers (in collaboration with: Univ. of Leiden), where various factors potentially associated with population structure of the flea beetles were studied: host plant use, phenotype with respect to the resistance trait, and geographic distance between subpopulations.

Infochemicals in multitrophic interactions

M. Dicke, R. Gols, W. Tigges, S.J. Boeke, J.G. de Boer, C.E.M. van den Boom, D. Charleston, N. Fatouros, D. Gnanvossou, I. Kappers, L.L.P. Luckerhoff, P. Mercke, V. van Oosten, R.M.P. van Poecke, O. Poitevin, M.C. Rocha-Granados, C. Schütte, I. Silva, Z. Szendrei, W. Tinzaara, B. Wertheim, and L. Yang

The focus of our research concerns the influence of herbivore-induced plant volatiles on species interactions in food webs. This is done through an integration of molecular, analytical chemical, and behavioural approaches. Our research falls within the themes 'chemical and molecular ecology' and 'behavioural ecology'.
Infochemicals are interesting because they cannot be directly used in bodybuilding. Yet, the responses they elicit have important consequences for fitness, and thus for interactions in a community. Through manipulative studies we investigate the effects of the infochemicals on food-web interactions.
Our research addresses two main systems: (1) crucifer-*Pieris-Cotesia* interactions with an emphasis on the plant *Arabidopsis thaliana* and (2) plant-spider mite-predatory mite interactions with an emphasis on interactions between Lima bean plants, the herbivorous mite *Tetranychus urticae* and the predatory mite *Phytoseiulus persimilis*.
Arabidopsis thaliana is the model plant of molecular genetics and many transgenic and mutant plants are available that are modified in well-characterized traits, including traits involved in induced defence. Remco van Poecke showed that Arabidopsis responds to *Pieris rapae* caterpillars in a way that is similar to the responses of other plant species in general and crucifer plants in particular. *Pieris* damage induces the emission of volatiles that attract the parasitoid *Cotesia rubecula*. The induced volatiles have been characterized and the expression of genes involved in their production has been demonstrated. One of the induced volatiles is methyl salicylate. Both the octadecanoid and the salicylic acid pathways are involved in this induced indirect defence. Genotypes that are altered in certain signal transduction pathways have been used to unravel the mechanisms of induced indirect defence of Arabidopsis. This research is now extended to cross-talk involved in induced defences of Arabidopsis against micro-organisms and herbivorous insects (project of Vivian van Oosten, collaboration with Phytopathology Group at Utrecht University).
Spider mites are polyphagous herbivores that can feed on several hundreds of plant species. In a survey of eleven plant species mainly from the Fabaceae and Solanaceae we found that the spider mites induce predator-attracting volatiles in all species. Chemical analyses by Cindy van den Boom showed that in many but not in all plant species novel volatiles were induced that were not induced by mechanical wounding. Methyl salicylate was induced by spider mites in the majority of the species investigated. In Lima bean plants jasmonic acid induces most of the compounds that are also induced by spider mites. An exception is methyl salicylate that is not induced by jasmonic acid. Through adding synthetic methyl salicylate to volatiles from jasmonate-induced Lima bean Jetske de Boer demonstrated that this compound has an important role in the attraction of predatory mites to the blend of spider mite induced Lima bean volatiles. Desire Gnanvossou demonstrated that infochemicals related to plant, herbivore and predator mediate prey location and interspecific interactions among different species of predatory mites in a system of cassava – cassava green mite and predatory mites. In two applied projects we investigate (a) the effects of a disease of

the predatory mite on its attraction to spider-mite induced volatiles and its effectiveness in extermination of prey populations and (b) the molecular aspects of gene induction involved in biosynthesis of spider-mite induced volatiles in cucumber and the possibility to develop molecular markers for breeding for cucumber lines with an improved induced volatile emission.

Evolutionary ecology

L. E.M. Vet, H.M. Smid; T. Bukovinszky, M.A.K. Bleeker, R. Buitenhuis, D. Charleston, L. Gohole, M. Vos, and B. Wertheim.

The research focuses on the ecology and evolution of multitrophic systems of plants, herbivorous insects and their natural enemies. Using a behavioural ecological, experimental chemical ecological, sensory physiological and neurobiological approach we study the functioning of natural enemies in a spatially diverse multitrophic context. 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. In addition we study sensory physiological and neurobiological aspects, specifically the perception and information processing (learning and memory) of herbivore-induced plant volatiles by insect parasitoids.

The research ranges from fundamental to strategic. The fundamental questions relate to understanding the evolution of species traits and species interactions within communities. Understanding the functioning of herbivores and their natural enemies in natural and agro-cosystems is crucial for the strategic development of sustainable agroecosystems that are primarily based on the prevention of pests and diseases (life-support function of biodiversity).

In 2001 and 2002 several PhD students successfully finished their PhD project. Matthijs Vos showed how parasitoids behaviourally deal with having only incomplete information on the presence of their hosts and how this incomplete information can significantly affect community dynamics. Bregje Wertheim conducted broad experimental studies on the ecology and evolution of *Drosophila* aggregation pheromones in a multitrophic context. Joep Burger conducted theoretical, experimental and fieldwork on the evolution of host handling behaviour (oviposition versus host feeding) in the famous parasitoid *Encarsia formosa.*

Selection of results: In collaboration with Hans Smid and Joop van Loon we added a neurobiological research line to the existing behavioural ecological research on plant odour learning in parasitoids (Maartje Bleeker, project entitled: "Learning-related differences at the neural level in two closely related parasitic wasps". The morphology of the olfactory pathway in both wasp species is now described, providing a solid basis for further research. Detailed information on the functional morphology and sexual dimorphism of the olfactory sensilla (Bleeker *et al.*, in prep.), and the primary olfactory neuropil, the antennal lobe (Smid *et al.,* 2003) is now available for both species (see under van Loon). Furthermore, it was studied which plant odours can be perceived by both wasp species, by combining electrical antennal recordings with gas chromatography of plant odours (see under van Loon and Smid *et al.,* 2002*)*. The general picture from these three studies is that the resemblance between both species at the morphological and anatomical level is very high, which makes this model system even more attractive to further focus on the observed differences in learning from behaviour to gene expression.

Tropical entomology

A. van Huis, J. Spitzen, C. Stolk, and G. Woldewahid

Biological control of bruchids in cowpea. Cowpea (*Vigna unguiculata*) is often infested with the destructive stored-product beetle *Callosobruchus maculatus*. A potential biocontrol agent of this beetle is the egg

parasitoid *Uscana lariophaga*. At low densities the control of the beetle is most useful (at high beetle densities the stored product is already lost); yet, *U. lariophaga* performs less well at low than at high beetle densities. The most important factor influencing the behaviour of *U. lariophaga* was an encounter with a host egg: this changed the walking trajectory from 'straight' to 'tortuous' and it increased the residence time per bean. *U. lariophaga* seemed attracted to host eggs from a distance of about 4-6 beans, and it showed a preference to move onto beans with an egg. Host finding is shown to be a function of distance, of time, of host patch size and of the spatial position of *U. lariophaga* relative to the host patch. Females were able to find hosts up to 75 cm horizontal distance from the release point, which as the largest distance tested. At 10 cm from the host patch, host finding probability ranged from 0.2 to 0.45 at these respective foraging times. Finding probabilities doubled compared to horizontal distances when *U. lariophaga* was released below the host patch, and halved when it was released above the host patch. The median net displacement rate in the direction of the host patch was estimated at two beans per hour (1.4 cm/h) when *U. lariophaga* was released at 2.5 cm from the host patch. Difficulty in host finding, due to large distances between host clusters, may be one of the main causes of the poor performance of *U. lariophaga* at low host densities. In addition, the reduced longevity of *U. lariophaga* at low host densities does not allow it to 'wait' until hosts are more abundant. *Uscana lariophaga* appears to be attracted by kairomones associated with host eggs; but these kairomones cannot easily be applied to improve biological control.
Additional releases of *U. lariophaga* could improve biological control at low host densities.
Habitat and spatial distribution of the desert locust *Schistocerca gregaria* in its solitary phase during winter breeding in the Red Sea coastal plain of Sudan (in collaboration with W. van der Werf). The desert locust is a major threat to forage and crop production in the semi-arid parts of Africa and Asia. Affected countries carry out survey operations in order to detect and locate outbreak populations of the insect, especially after widespread and heavy rainfall. Considering the huge area where locusts may occur, it is important to maximize the efficiency of survey and control by identifying in which habitats locusts are most likely to occur, and by establishing which habitat factors are correlated with locust occurrence.
The Wageningen University and FAO/EMPRES in collaboration with the Plant Protection department of Sudan studied the dynamics of locust populations during three winter breeding seasons in an area of 20 x 120 km in the Red Sea plains of Sudan. Four plant communities were identified and characterized by the dominance of *Suaeda monoica*, *Heliotropium* spp., *Panicum turgidum* and scrub *Acacia tortilis*. The spatial extent of the *S. monoica* and *Heliotropium* were confined to fine sandy, moist soils in the low elevation coastal strip, whereas the *P. turgidum* and *A. tortilis* scrub plant communities were associated with the coarse, dry sand, in more grazed, relatively compacted soils and in more elevated inland sites. Principal component analysis (PCA) showed that in each of the three winter seasons, locust densities were associated with the *Heliotropium* plant community, fine soil particles and moisture availability, and negatively correlated with increased grazing pressure and elevation. The *Heliotropium* plant community contained 93% of the locusts in 1999 and 100% in 2000, while it covered only 5% of the surveyed area. Thus, the *Heliotropium* plant community is most likely to have the highest solitary locust densities and should be prioritized in early detection surveys.

Vector biology and control

W. Takken, J. Spitzen, B.G.J. Knols, C.J.M. Koenraadt, H.V. Pates, R.W. Mukabana, K. Paaijmans, Y.T. Qiu, E-J. Scholte, and R.C. Smallegange

Mosquito-host interactions (theme: Chemical and molecular ecology): in this programme, we study the role of host-specific cues in the host-seeking behaviour of mosquitoes. Studies focus on the physiological and behavioural response of human odours in the tropical malaria mosquito *Anopheles gambiae*. Human skin emanations are collected on glass marbles and offered to the mosquitoes in an olfactometer. In this way, highly attractive and poorly attractive persons have been identified. The odours of these individuals were

chemically analysed using GC-MS techniques (in close collaboration with the Laboratory of Organic Chemistry, WUR). A comparison of odour profiles of the different individuals shows that differences in chemical composition exist between the attractive and poorly attractive persons, but these differences are based more on a complex of chemicals than on one or few specific compounds only. Electrophysiological and olfactometer studies with these compounds show that some compounds are highly volatile. It was shown that a mixture of carboxylic acids, ammonia and L-lactic acid confers a higher attractiveness than either of the compounds alone. Studies on additional compounds are in progress. A linked EAD-GC-MS set-up for the study of human volatiles with *Anopheles gambiae* was developed and made operational.
Population ecology of malaria vectors (Theme: Behavioural and population ecology): This study concerns a field/laboratory study in western Kenya where the larval and adult ecology of *Anopheles gambiae* s.l. is being studied in different environments, c.q. lowland and highland villages. It was found that in a village where *An. gambiae* and *An. arabiensis* share breeding sites, the latter species was significantly more negatively affected by lower temperatures than the former. Larvae of An. gambiae were found in the highland village, but adult mosquitoes could not be detected there during a two-year monthly survey involving 10 houses. In spite of the lack of adult mosquitoes, malaria parasites were detected in up to 20% of primary school children. In the lowland village this was 60-80% with little seasonal variation. In all breeding sites larval mortality was high, and it was demonstrated that this was partially caused by interspecific and intraspecific predation and cannibalism. In The Netherlands malaria mosquitoes were studied to reveal the geographical distribution and species composition of adult and larval populations of Anopheles atroparvus and An. messeae. It was found that *An. atroparvus* populations are higly fragmented and limited to the Delta of the rivers Meuse and Rhine. *An. messeae* was found from the German boarder until the coast with the North Sea. Population densities varied locally, and so far there is no clear indication which factors determine the population density of both species in the study area.
Risk of Lyme disease in The Netherlands: the number of people acquiring Lyme disease in The Netherlands has increased dramatically in the last 10 years. There is poor knowledge about the population biology and dynamics of Lyme disease vectors (the tick *Ixodes ricinus*) in The Netherlands. A study was initiated to investigate the seasonal phenology and association between *Ix. ricinus* and its vertebrate hosts and habitat. The study is conducted in a dune area south of Haarlem and within the National Park Hoge Veluwe, in the centre of the country. A preliminary analyses shows that ticks are active from early in the year until late in December, provided the daily temperature does not drop below 5°C. Significant differences in tick densities were observed between the dune and the inland areas, which appeared to be correlated with differences in microclimate. This study is done in collaboration with the Section Nature Conservation and Plant Ecology of WUR.

From behavioural and population ecology to functional biodiversity and agro-ecology
J.C. van Lenteren, M. Ardeh, T. Bukovinszky, J. Burger, R. Gols, G. Gonzalez, Y. Huang, A. Loomans, E. Meekes, H. Trefas, W. Tigges, Y. Tricault, L.E.M. Vet, R. de Vis, F.L. Wäckers, K. Winkler, and Y. Jongema

The research activities of our group have changed drastically over the past two years: from behavioural and population ecology to a focus on functional biodiversity and agroecology.
Behavioural and population ecology. Several PhD projects concerning development of biological control methods have been finished during this report period. Raf de Vis studied in greenhouses in Columbia whether native parasitoid *Amitus fuscipennis* would be better in controlling whitefly than *Encarsia formosa.* He showed that both parasitoids contributed to reduction of whitefly, but that *Encarsia* was the best biocontrol agents under greenhouse conditions. Ellis Meekes evaluated the whitefly control capabilities of a number of *Aschersonia* species and cultivars in different ornamental and vegetable crops. She found that several strains

of the entomopathogenic fungus *Aschersonia aleyrodis* did reduce *Trialeurodes vaporariorum* and *Bemisia tabaci* effectively, and much better than the currently used fungus *Verticillium lecanii*.
Mohammed Ardeh studies arrhenotokous and thelytokous strains of *Eretmocerus* species, and the benefits and costs of the use of thelytokous parasitoids in control of whiteflies. Gladys Gonzalez attempts to develop a biological control programme for whiteflies on tomatoes in Panama based on the use of native parasitoids (*Eretmocerus* and *Encarsia* spp.).
For years, we have studied the biology of *Encarsia formosa* in greenhouses. In a combination of field work in its natural setting, Costa Rica, laboratory and modelling work in Wageningen, Joep Burger showed that at very low host densities, which often occur in the natural habitat of whitefly, killing hosts by host feeding is maladaptive; the hosts should primarily be used for parasitization for production of offspring. At the high host densities normally found in greenhouses, parasitoids that host feed produce more eggs per unit of time than those that were not allowed to host feed.
Functional Biodiversity and Agroecology. The general objective of the new, large project on Functional Biodiversity and Agroecology is to determine how increased biodiversity (here functional group diversity) leads to reduced pest development. Together with other Wageningen University and Research Centre groups, work is also done on prevention of diseases and weeds.
Tibor Bukovinszky found that available information and our own field results do not yet allow generalisations about the behaviour of specific or generalist herbivores and their natural enemies in monocultures or mixed cropping systems. Still, knowledge of the searching behaviour of pests and their natural enemies is essential to predict the effect that mixed cropping will have on pest reduction and natural enemy increase. This means that quite some laboratory and fieldwork on the foraging behaviour of guilds of insects will have to be performed in the coming years. Another important finding was that plant stress and consequent changes in nutritional quality of plants are playing a role in herbivore responses to intercropping. Such confounded effects of plant competition in intercropping hampers the evaluation of herbivore responses in pest-suppressive agro-ecosystems.
Karin Winkler and Felix Waeckers studied the effect of the provision of nectar and pollen in field edges on the development of natural enemy populations. Although there is growing interest for the use of flowering field margins to boost natural enemies, it is often forgotten that pest species may as well profit from additional nectar sources, so these potential negative effects were studied as well. We found several flowering plant species which selectively fulfil the needs of predators and parasitoids, without supporting pest organisms.
Antoon Loomans and Ying Huang have studied the potential risks of import and release of exotic natural enemies, another aspect of functional biodiversity. Currently, many new exotic natural enemies are available for release in new areas. However, these exotic species are often not thoroughly evaluated for potential risks they might cause for non-target organisms and the ecosystems in which they will be released. In a large EU-funded project we have evaluated with four other research groups in Europe the risks of 4 groups of natural enemies (entomopathogens, polyphagous predators, and oligo- and polyphagous parasitoids), and we developed a protocol for risk assessment of natural enemies which includes a quantified risk ranking system.

Spatio-temporal dynamics of herbivores and their antagonists in diversified agro-ecosystems.
R.P.J. Potting

There is a rapidly increasing interest in using agro-ecosystem diversification as a pest management strategy. Using this strategy pest-disturbing and/or natural enemy-enhancing plants are embedded in agro-ecosystems, with the aim of decreasing the pest density. However, increasing the vegetational diversity of agroecosystems can have variable results depending on the species of herbivore, natural enemy and vegetation involved. The main objective of this project is to develop a mechanistic framework to

understand and predict the response of herbivores and natural enemies in relation to composition and spatial arrangements of vegetation in agricultural systems. An object-oriented individual-based simulation framework was developed that includes behavioural-based stochasticity and spatial structures based on vegetation composition and structure. With the model we determine optimal diversification strategy sets. We thereby generate guidelines for practitioners trying to establish an environmental benign control strategy in the field. In addition, the model indicates which aspects of the ecology of the plants and insects are determining factors. The research in this project is strongly embedded in the theme 'Functional biodiversity and Agroecology'. It provides a conceptual framework to understand insect response to diversified ecosystems and enables an extrapolation of our knowledge of individual behaviour to the spatial and temporal population dynamics at a field scale level. Within the theme 'Functional biodiversity and Agroecology', the aim of this project is to integrate experimentation and simulation. As a first step, the simulation framework was adapted to the specific
ecology of crucifer pests (*Plutella xylostella* and *Pieris rapae*) to understand field-experimental data of insect response to specific intercrop strategies (see T. Bukovinsky project on enhanced biodiversity).

Aphid-plant interactions and host plant resistance
W.F. Tjallingii, and F. Kindt

The electrical penetration graph (EPG) records plant penetration by the piercing mouthparts of aphids and thrips. A new electronic approach was developed and tested to separate signals from different electrical origin as they occur in the EPG: 1) voltage fluctuations due to conductance changes in the insect-plant combination and 2) voltage fluctuations generated (electromotive force, emf) by the insect-plant combination. The new device that was constructed allowed a simultaneous recording of an EPG with both electrical origins and an EPG with only the conductance changes. An EPG from only emf origin can be recorded as well but not simultaneously. A study comparing EPGs from white flies and aphids was conducted together with scientists from UCR (University of California, Riverside). The recordings allowed the analysis of intracellular punctures by the mouthparts of these two closely related insect groups, which appeared rather different. One important implication of these cell punctures is the transmission of plant viruses. The underlying insect activities during such punctures need to be investigated further now but the new method provides good prospectives. A different aspect to approach with this new device is the detection of salivary secretion periods during stylet pathway, i.e. the mouthpart penetration of the plant's tissue from the epidermis to the phloem vessels on which aphids feed. Such salivary secretions are studied and it is suggested that they presumably play a mayor role in plant reactions to aphid attack. A cascade reactions mostly results which presently interests the world of plant physiologists and ecologists. To start phloem feeding, a different salivary secretion is likely to avoid the effects of phloem wound reactions, thus allowing phloem sap tapping by aphids. The possibility that certain cases of aphid resistance in plants might be based on ineffective avoidance of these wound responses.
Also the transmission of plant viruses is the main aim of a Ph.D. project (STW) but this focuses on thrips, which is a completely different insect with EPGs that are in no way comparable to the aphid EPG. The virus acquisition and inoculation activities were studied by EPG recording during plant penetrations on thrips resistant and virus resistant sweet pepper accessions. Insect survival and population development on these accessions seems to explain a good deal of the decreased transmission on thrips resistant plants. Quantitative and qualitative differences in plant penetration are now studied as potential additional factors.

Projects within graduate school Experimental Plant Sciences:

- EPS2-2b28. Insect-plant interactions during stylet penetration by aphids. W.F. Tjallingii.
- EPS2-2b75. Antagonistic and synergistic effects of resistances in sweet pepper on transmission of Tomato Spotted Wilt Virus and population development of Western Flower Thrips. 1999-2003. F. Kindt & W.F. Tjallingii.
- EPS2-2d06. Induction of plant volatiles by herbivory: signal transduction and behavioural modification in a multitrophic context. M. Dicke, W. Tigges, R. Gols, Z. Szendrei.
- EPS2-2d04. Variation in foraging behaviour of the predatory mite *Phytoseiulus persimilis*. 1992-2003. 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- 2d15. Indirect defense of plants: variation among plant species and determination of the bioactivity and chemical nature of the plant volatiles involved. 1997-2003. C.E.M. van den Boom, T.A. van Beek, M. Dicke & A.E. de Groot.
- EPS2-2d16. Signal transduction in herbivore-induced production of volatiles by plants: *Arabidopsis-Pieris-Cotesia* interactions. 1998-2002. R.M.P. van Poecke & M. Dicke
- EPS2-2d17 . Plant secondary metabolites as repellents and toxins to the bruchid beetle *Callosobruchus maculatus*, a specialist herbivore of cowpeas, *Vigna unguiculata* 1998-2002. S. Boeke, J.J.A. van Loon, A. van Huis & M. Dicke.
- EPS2-2d18. Infochemical use by *Typhlodromalus manihoti* and *T. aripo*, two predators of the cassava green mite *Mononychellus tanajoa* in Africa. 1998-2002. D. Gnanvossou, R. Hanna & M. Dicke.
- EPS2-2d19. Quantitative and qualitative variation in odour blend composition: effect on behavioural responses of predatory mites 1999-2003. J.G. de Boer & M. Dicke, in collaboration with M.W. Sabelis (UvA).
- EPS2-2d20. A new disease in the predatory mite *Phytoseiulus persimilis*: Pathogen identification, development of a detection method and prevention and cure in mass rearing. 1998-2004. C. Schütte, I.M.M.S. Silva, O. Poitevin, M. Dicke and R. Stouthamer
- EPS2-2d24 new. Chemical ecology and management of the banana weevil *Cosmopolites sordidus*. W. Tinzaara, C. Gold, A. van Huis and M. Dicke. 2000-2005.
- EPS2-2d21. The compatibility between biological control of the diamondback moth, *Plutella xylostella*, host plant resistance and chemical control using novel botanical pesticides: Evaluation in a tritrophic context. 2000-2004. D. Charleston, R. Kfir, L.E.M. Vet and M. Dicke.
- EPS2-2d22. Induced indirect plant defence and plant fitness: testing the "evolutionary nlistment" hypothesis. 2001-2005. L. Hess, J.J.A. van Loon, J.A. Harvey & M. Dicke
- EPS2-2d23. Cross-talk between signal-transduction pathways in induced defence of Arabidopsis against microbial pathogens and herbivorous insects. 2001-2005. V.R. van Oosten, C.M.J. Pieterse, L.C. van Loon & M. Dicke.
- EPS2-2c27. Induced defence of Arabidopsis against herbivorous insects: cross-talk with induced defences against microbial pathogens. 2002-2004. R.M.P. van Poecke & M. Dicke.
- EPS2-2d27 Genomics approach to integration of host plant insect resistance and biological control. 2001-2005. 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. 2002-2006. I.F. Kappers, L. Luckerhoff, H.J. Bouwmeester & M. Dicke.
- EPS2-4a22. Mode of action of sex-modifying supernumerary chromosomes, 2000-2004. J. van Vugt, H. de Jong (Genetics, WU), R. Stouthamer and L. Beukeboom (RUG).

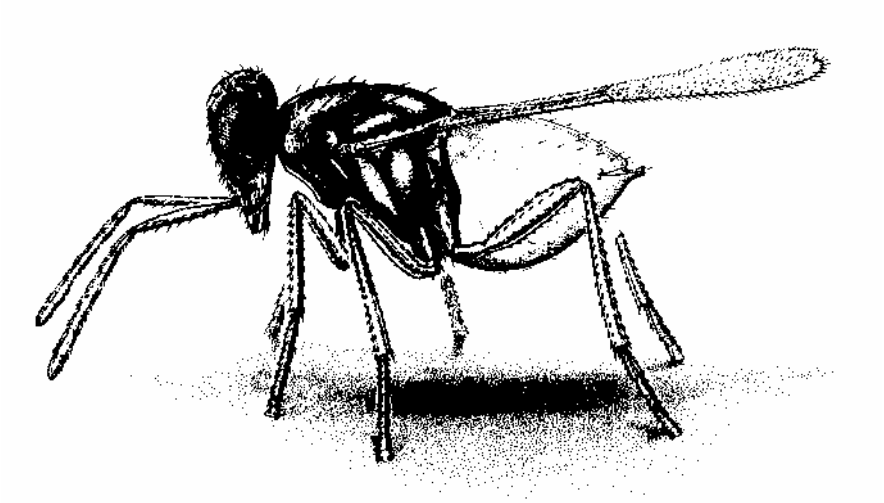
Projects within graduate school Production Ecology and Resource Conservation:

- PE33-00b. Control of *Callosobruchus maculatus* and *Bruchidius atrolineatus* (Col.: Bruchidae), insects in storage or cowpea (*Vigna unguiculta*) by the egg parasitoid *Uscana* sp. (Hym.: Trichogrammatidae). A. van Huis, C. Stolk and G.J.K. Pesch.
- PE&RC32. Extrafloral nectar in a tri-trophic context. 2000-2003. F.L. Wäckers.
- PE31-98a. Effects of molasses grass (*Melinis minutiflora)* on the foraging behaviour and searching efficiency of cereal stemborer parasitoids in cereal based cropping systems. 1997-2003. L.S. Gohole, L.E.M. Vet, Z.R. Khan and W.A. Overholt.
- PE&RC32-00aj. Factors that affect host searching by anopheline mosquitoes. W. Takken.
- PE32-94a. Understanding biological control of whiteflies by natural enemies. J.C. van Lenteren, Y. Tricault.
- PE32-97d. To feed or to reproduce, that's the question: an analysis of foraging decisions in the parasitoid *Encarsia formosa.* 1997-2002. J. Burger, L.E.M. Vet & J.C. van Lenteren.
- PE&RC31-00f. Genomic conflicts over sex ratios in Trichogramma wasps 1999-2003. M. E. Huigens & R. Stouthamer.
- PE&RC Wolbachia genome project 2000-2003. F.Vavre and R. Stouthamer.
- PE&RC-ipr096. Genetics and physiology of *Wolbachia*-host interactions in *Telenomus nawai* populations: their implications on the reproduction and behavior of *Telenomus nawai*. 2000-2004. Gilsang Jeong & R. Stouthamer.
- PE&RC39-99d Enhanced biodiversity of arthropod natural enemies for sustainable control of herbivores. 2000 – 2004. T. Bukovinsky, J.C. van Lenteren & L.E.M. Vet.
- PE&RC-33-01a. Functional biodiversity: strategic use of nectar and pollen sources to boost biological control. 2000 – 2004. K. Winkler, J.C. van Lenteren, F. Wäckers.
- PE&RC32-01e. The role of the natural enemies in reducing whitefly populations in Panama. G.I. Gonzalez, J.C. van Lenteren. 1999 – 2003.
- PE32-4b. The role of predators and parasites in the control of aphids in apple orchards. 1987-2002. P.J.M. Mols.
- PE&RC31-00u. Learning-related differences at the neural level in two closely related parasitic wasps: a comparison between a generalist and a specialist. 2000-2004. M.A.K. Bleeker, H.M. Smid, J.J.A. van Loon & L.E.M. Vet.
- PE32-94h. Biological control of thrips pests: Evaluation of hymenopterous parasitoids as potential biological control agents of Western Flower Thrips (*Frankliniella occidentalis*). 1991-2003. A.J.M. Loomans, J.C. van Lenteren.
- PE33-97j. Biology of *Amitus fuscipennis*, natural enemy of whiteflies. 1996-2001. M. Manzano & J.C. van Lenteren.
- PE&RC. Evaluation of *Encarsia formosa* and *Amitus fuscipennis* for control of whiteflies in greenhouses in Colombia. 1996-2001. R. de Vis &, J.C. van Lenteren.
- PE&RC. Enhancing the biocontrol of the Western Flower Thrips (*Frankliniella occidentalis*) with the predatory bug (*Orius laevigatus*) on greenhouse cucumber. 1998-2003. J. Hulshof, A.J.M. Loomans, J.C. van Lenteren.
- PE33-98a. Foraging strategies in Entomopathogenic Nematodes. 1998-2001. M.I.C. Boff, J.C. van Lenteren, P.H. Smits (DLO).
- PE&RC31-00t. Introduction of the gene(s) for zoophily from *Anopheles quadriannulatus* into anthropophilic *An. gambiae sensu stricto* by backcrossing. 1998-2002. H.V. Pates and W. Takken.
- PE&RC32-01b. Integrating Geographical Information Systems and Cellular Automata for the Assessment of Malaria Risk and Control. 1998-2002. C.J.M. Koenraadt, and W. Takken. In cooperation with Maastricht University.

- PE&RC. Climate change impacts on vector-borne diseases. 1998-2001. W. Takken & C.J.M. Koenraadt. Funded by National Research Programme on Air Pollution and Climate Change. In cooperation with Maastricht University.
- PE&RC32-00at. Feeding patterns of African malaria vectors: effect of parasite infection and host (age, sex and olfactory) characteristics. 1998-2002. W.R. Mukabana and W. Takken.
- PE32-96c/PE33-97i. Biological control of bruchids in stored cowpea in West-Africa. 1997-2002. C. Stolk & A. van Huis.
- PE&RC23-00i. Genetic variability in *Cotesia flavipes* Cameron and its significance for population establishment in the biological control of lepidopteran stemborers, 1998-2003 E.I. Niyibigira, R. Stouthamer & W.A. Overholt.
- PE39-97a. Designing improved Desert Locust survey operations and control strategies using scenario studies. 1998-2002. W.T. Gebremedhin & A. van Huis.
- PE-new. Factors important for the optimal performance of Trichogramma spp. in biological control. 1999-2003. R.P. de Almeida, R. Stouthamer & J.C. van Lenteren.
- PE&RC. Social parasitism in the Cape honeybee Apis mellifera capensis. 2001-2003. W.J. Boot, J. Calis & L.E.M. Vet.
- PE&RC prep29. Evaluation of the biological control capacity of Eretmocerus spp For the control of whiteflies on Gerbera. 2001-2005. M. Ardeh & J.C. van Lenteren.
- PE&RC ipr103. Factors important for the biological control performance of Trichogramma. 2002-2003. R. Porfiro de Almeida, R. Stouthamer & J.C. van Lenteren.

Project within graduate school Functional Ecology:

- FO. Why do drosophilid flies produce volatile aggregation pheromones when it guides parasitoids to their offspring? 1996-2001. B. Wertheim, L.E.M. Vet, M. Dicke & J.C. van Lenteren.



REPRESENTATION IN EXTERNAL COMMITTEES

International:

- Contractor EU-Tempus project Sustainable Crop Protection Curriculae, Hungary-West Europe (van Lenteren)
- Contractor EU project Environmental Risks of Importing Exotic Natural Enemies for Biological Control (ERBIC) (van Lenteren)
- Council of International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palearctic Regional Section (IOBC-WPRS) (van Lenteren)
- Council of the International Congress of Entomology (1998-2004) (Takken, member)
- European Branch Society of Vector Ecology 2002-2004 (Takken, president)
- Expert Advisory Committee Canadian Network of Biocontrol Research (van Lenteren)
- FAO Technical Group of the Desert Locust Control Committee (Van Huis)
- Honorary Professor Beijing Normal University (van Lenteren)
- Honorary Professor University of Perugia, Italy (van Lenteren)
- International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC-IUBS) (2000-2004) (van Lenteren, Vice President)
- International Working Group on Mediators of Bloodfeeding Arthropods (Takken, secretary)
- OECD working group Regulation of Import and Release of Exotic Natural Enemies (van Lenteren)
- Scientific Advisory Board 7th Aphidophaga Congress, Azores (Portugal 2002) (van Lenteren)
- Scientific Advisory Committee Siconbiol 2003, Piracicaba, Brazil (van Lenteren)
- Scientific Advisory Committee 3rd Bemisia Congress, Barcelona, Spain, 2003 (van Lenteren)
- PhD examination committees, international students (van Lenteren, van Loon, Vet)
- Steering Committee Working Group 'Induced Resistance', International Organization for Biological Control, IOBC (Dicke)
- Organisation Committee International Symposium "Multitrophic Interactions and Environmentally Benign Control of Arthropod Pests", Kyoto, January 2002 (Dicke)
- Panel of Experts on Environmental Management of Vectors (PEEM), WHO, Geneva (Takken)
- 'Professeure associée' at Laval University, Quebec, Canada (Vet)

National:

- Advisor of Search committee Professor of Animal Ecology RUG (Vet)
- Biological advisory board, Biologische Raad, KNAW (Vet)
- Board for the Authorisation of Pesticides "CTB" (van Lenteren).
- Board IAC course on crop protection (van Lenteren).
- Board of 'Landbouwexport fonds 1918', Wageningen (Dicke, van Lenteren)
- Board LEB fund (van Lenteren).
- Board of Teaching Institite Life Sciences WU (van Lenteren).
- Board Uyttenboogaart-Eliasen fund (van Lenteren).
- Board Van Groenendael-Krijger fund (van Lenteren).
- Committee for Engineer's Examination in Crop Sciences (van Lenteren).
- Committee for Functional Agrobiodiversity of LTO (van Lenteren)
- Committee for Genetic Modification (Cogem), Ministry of Environment (Dicke)
- Committee 'Studium Generale' of WU, involved in extracurricular teaching (Dicke)
- Contact group Behavioural Genetics (Contactgroep Gedragsgenetica; Vet).

- Department of Plant Sciences, Wageningen University, advisory committees and working groups formation of Knowledge Unit Plant Sciences WUR (van Lenteren, Dicke)
- Dutch Entomological Society (van Lenteren, Vice-president).
- Dutch Entomological Society, Section Experimental and Applied Entomology (SETE-NEV) (van Huis, secretary).
- Earth and Life Sciences council of the Netherlands Organization for Scientific Research (Gebiedsbestuur ALW-NWO) (Vet, member)
- Graduate School Production Ecology & Resource Conservation, Scientific Advisory Board, (Vet).
- Graduate School of Production Ecology & Resource Conservation, Educational Committee (Takken).
- Graduate School of Production Ecology & Resource Conservation, PhD Student Platform (Meekes)
- Graduate School of Production Ecology & Resource Conservation, Scientific Committee (van Huis).
- Graduate School Production Ecology & Resource Conservation (van Lenteren, chairman).
- Jury Eureka! Price 2002 (best science journalist, best science television programme, best popular science book) (Vet)
- Jury Netherlands Film Festival 2001, scientific contributions (Vet)
- Klankbordgroep 'Avond van de Wetenschap' (Vet)
- Library Committee, Centre for Crop Protection, Wageningen University (Dicke).
- National Graduate School Experimental Plant Sciences, PhD Council (Boeke, member).
- 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 Committee on the Prevention of Head Lice Infections, Min. of Public Health (Takken)
- Management Advice Committee of National Science Foundation ALW (Beleids Advies Commissie ALW) (Dicke)
- PhD Examination committees at different national universities (Dicke, van Loon, van Huis, van Lenteren, Takken, Vet).
- Programme Committee Plant Sciences, Wageningen University (Takken).
- Project Enhanced biodiversity, Alterra, Laboratory of Entomology, Laboratory of Phytopathology, Laboratory of Theoretical Production Ecology, Centre for Plant Ecology and Weed Science (van Lenteren, coordinator, Vet)
- Representative Department for ROC Biology (Dicke).
- Selection Committee of projects of the Netherlands Foundation for Scient. Res. WOTRO (van Huis).
- Selection committees NWO-personal grants: Pionier, Talent, Puls, Vernieuwingsimpuls etc. (Vet)
- Structure committee KNAW (to restructure the Royal Netherl. Ac. of Arts and Sciences) (Vet)
- Stuurgroep Utrecht-Wageningen Genomics Centre (Vet)
- Stuurgroep Biosystem Genomics WUR (Vet)
- Teylers Tweede Genootschap, Teylers Museum, Haarlem (Vet)
- Wageningen Plant Sciences Group – Wageningen UR – Expertise-unit Biointeractions and Health (Dicke, coordinator)
- Wageningen University Crop Protection groups within Department of Plant Sciences, Wageningen University. (Dicke, coordinator)

Journals:

- Annual Review of Entomology (Vet, editorial board)
- Basic and Applied Ecology. Guest Editor for special issue on 'Induced responses of plants towards herbivory' (Dicke).
- Biochemical Systematics and Ecology (Dicke, editorial board).
- Biological Control: Theory and Application in Pest Management (van Lenteren, editorial board).

- Bionieuws, column (Vet)
- Chemoecology (Vet, editorial board).
- Ecological Entomology, editorial board (Dicke, editorial board)
- Entomologia experimentalis et applicata (co-editor, van Loon).
- Entomological Bulletin Guido Grandi, University of Bologna (van Lenteren, editorial board)
- Entomologische Berichten – bimonthly column (Dicke)
- Insect Science and its Application (van Huis, Editorial Advisory Board).
- International Journal of Pest Management (van Lenteren, editorial board).
- IOBC bulletins (van Lenteren, editor).
- IPM practioner (van Lenteren, editorial board).
- Journal of Insect Behavior (van Lenteren, Vet, editorial board).
- Journal of Chemical Ecology (Dicke, editorial board).
- Journal of Ethology (Dicke, advisory board)
- Neotropical Entomology (van Lenteren, editorial board)

PROJECTS FUNDED EXTERNALLY

- **1997-2002** Plant secondary metabolites as repellents and toxins to *Callosobruchus maculatus*, a specialist herbivore of cowpeas *Vigna unguiculata*. Funded by DGIS.
- **2000-2002** Evaluating environmental risks of biological control introductions into Europe (ERBIC) Funded by EU.
- **1998-2003** Genetic variability in Cotesia flavipes Cameron and its significance for population establishment in the biological control of lepidopteran stemborers. Funded by WOTRO.
- **1998-2003** Improvement of Desert Locust Survey and control strategies. Funded by DGIS.
- **1999-2003** Quantitative and qualitative variation in odour blend composition: effect on behavioural responses of predatory mites. Funded by ALW-NWO.
- **1999-2003** Antagonistic and synergistic effects of resistances in sweet pepper on transmission of Tomato Spotted Wilt Virus and population development of Western Flower Thrips. Funded by Technology Foundation (STW).
- **1999-2003** Genomic conflicts over sex ratios in *Trichogramma* Wasps. Funded by NWO/ALW
- **2000-2003** Extrafloral nectar in a tri-trophic context. Funded by KNAW.
- **2000-2003** *Wolbachia* genome project (EUWOL). Funded by EU.
- **2001-2003** Social parasitism in the Cape honeybee Apis mellifera capensis. Funded by WOTRO.
- **2002-2003** Factors important for the biological control performance of Trichogramma. Funded by EMBRAPA.
- **2001-2003** Assessment of malariarisk in areas with different transmission characteristics as determined by environmental factors and mosquito bionomics. Funded by WOTRO.
- **2002-2003** Effect of crop sanitation on timing of attack, distribution and survivorship of the banana weevil Cosmopolitan sordidus (Germar) (Coleoptera: Curculionidae) in banana fields in Uganda. Funded by WOTRO
- **1998-2004** A new disease in the predatory mite *P. persimilis*: Pathogen identification, development of detection method and prevention and cure in mass rearing. Funded by Technology Foundation (STW).
- **2000–2004** Learning-related differences in olfactory information processing in two closely related parasitic wasps: phenotypic plasticity analysed from behaviour to neuron. Funded by NWO/ALW.
- **2000–2004** Enhanced biodiversity for sustainable crop protection Funded by NWO/ALW.
- **2000–2004** Functional biodiversity: strategic use of nectar and pollen sources to boost biological control. Funded by Robert Bosch Foundation.
- **2000–2004** The role of the natural enemies in reducing whitefly populations in Panama. Funded by Senacyt, Panama.
- **2000-2004** Mode of action of sex modifying supernumerary chromosomes. Funded by NWO-ALW.
- **2000-2004** Identification of human volatiles as attractants for *Anopheles gambiae sensu stricto*. In collaboration with the Laboratory of Organic Chemistry, Wageningen University. Funded by Technology Foundation (STW).
- **2000-2004** Entomopathogenic fungi for biological control of malaria and filariasis vectors on Mfangano island, Lake Victoria, Kenya. Funded by WOTRO.
- **2002-2004** Induced defence of Arabidopsis against herbivorous insects: cross-talk with induced defences against microbial pathogens. Funded by Graduate school Experimental Plant Sciences.
- **2000-2004** Chemical ecology and management of the banana weevil Cosmopolites sordidus (Germar) (Coleoptera: Curculionidae) Funded by IITA.
- **2001-2005** Genomics approach to integration of host plant insect resistance and biological control. Funded by Dutch and Chinese government.

- **2001-2005** Evaluation of the biological control capacity of Eretmocerus spp for the control of whiteflies on Gerbera. Funded by the Ministry of Agriculture of the Islamic Republic of Iran.
- **2001-2005** Induced indirect plant defence and plant fitness: testing the "evolutionary enlistment" hypothesis. Funded by NWO/ALW.
- **2001-2005** Cross-talk between signal-transduction pathways in induced defence of Arabidopsis against microbial pathogens and herbivorous insects. Funded by NWO/ALW.
- **2001-2005** Convergence of sciences: inclusive technology innovation processes for better integrated crop and soil management. Funded by International Research and Education Fund (INREF) and Directorate General of International Cooperation (DGIS) of the Netherlands' Ministry of Foreign Affairs.
- **2001-2006** Development of a method for breeding of cucumber for improved attraction of biological control agents. Funded by Technology Foundation (STW).

PUBLICATIONS 2001

- Almeida, R.P. de\Ciociola, A.I.\Stouthamer, R.\ Wolbachia-induced parthenogenesis: the first report in a Brazilian Trichogramma pretiosum population Proceedings of the Section Experimental and Applied Entomology of the Netherlands. Entomological Society 12 (2001). - p. 41-44;
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- Boff, M.I.C.\ The entomopathogenic nematode Heterorhabditis megidis: host searching behaviour, infectivity and reproduction. Wageningen Universiteit. Promotor: Prof. Dr. J.C. van Lenteren, co-promotor(en): Dr. P.H. Smits. - Wageningen : [s.n.], 2001. - ISBN 9058083640. - p. 153;
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- Bruin, J.\Dicke, M.\ Chemical information transfer between wounded and unwounded plants: backing up the future. Biochemical Systematics and Ecology 29 (2001). - ISSN 0305-1978. - p. 1103-1113;
- Bruin, G.C.A.\Meerman, F.\ New ways of developing agricultural technologies: the Zanzibar experience with participatory integrated pest management. Wageningen University and Research Centre/CTA, Modern, Bennekom, 2001. - p. 167;
- Calis, J.N.M.\ Parasite-host interactions between the Varroa mite and the honey bee. Dissertatie Wageningen Universiteit. Promotor: Prof. Dr. J.C. van Lenteren, co-promotor(en): Prof. Dr. M.W. Sabelis. - Wageningen, [s.n.], 2001. - ISBN 99-5808-446-9. - p. 144;
- Calis, J.\Boot, W.J.\Beetsma, J.\ Attractiveness of brood cells to Varroa jacobsoni in different honeybee races (Apis mellifera). In: Proceedings of the Third Asian Apicultural Association conference on Bee research and beekeeping development. M. Matsuka, D.Q. Tam, H. Enomoto et al (eds). - Hanoi : Bee Research and Development Center, Hanoi, 2001. - p. 202-205;
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- Koenraadt, S.\Tuiten, W.\Githeko, A.K.\Derks, K.\Schneider, P.\Takken, W.\ The price-tag of a malaria mosquito: results from a socio-economic field study in western Kenya. Proceedings of the section Experimental and Applied Entomology, N.E.V., Amsterdam 12 (2001). - p. 157-158;
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- Lei, H.\Lenteren, J.C. van\Xu, R.M.\ Effects of plant tissue factors of the acceptance of four greenhouse vegetable host plants by the greenhouse whitefly: an electrical penetration graph (EPG) study. European Journal of Entomology 98 (2001). - p. 31-36;
- Lenteren, J.C. van\ Harvesting Safely from Biodiversity: Natural Enemies as Sustainable and Environmentally Friendly Solutions for Pest Control. In: Balancing Nature: Assessing the Impact of Importing Non-native Biological Control Agents (an International Perspective) / J.A. Lockwood, F.G. Howarth, M.F. Purcell (eds) - [S.l.] : Thomas Say Publications in Entomology, Entomological Society of America, 2001. - ISBN 0-938522-93-0. - p. 15-30;
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- Lenteren, J.C. van\ Will importation and release of natural enemies be regulated soon? Sting 2001 (2001) 22 september . - p. 18-20;
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