ANNUAL REPORT 2000

LABORATORY OF ENTOMOLOGY

Laboratory of Entomology
Wageningen University
Binnenhaven 7, 6709 PD Wageningen
P.O. Box 8031, 6700 EH Wageningen
Telephone: +31 (0)317 484075
Telefax: +31 (0)317 484821
Electronic mail: office@sec.ento.wau.nl
Electronic mail: office@sec.ento.wag-ur.nl
Compilation: M. Dicke

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

1. FOREWORD

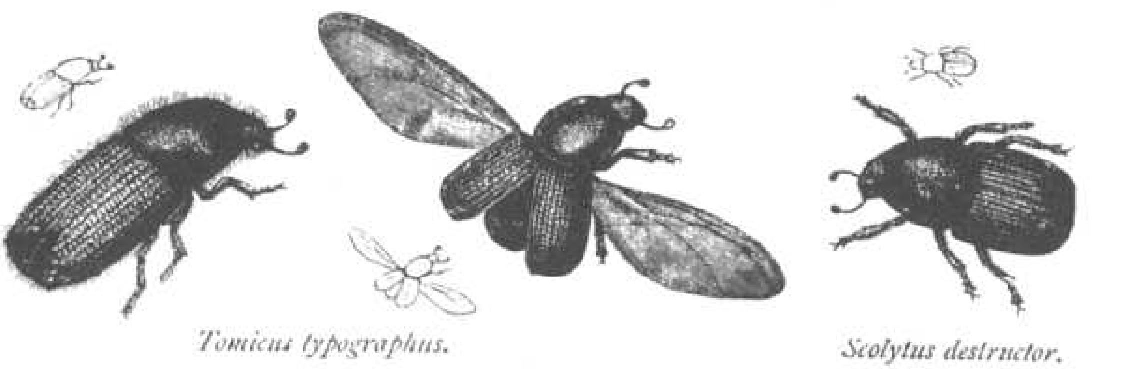
In the year 2000 we have seen changes toward a renewal of the laboratory of Entomology. What happened? Another reorganization of Wageningen University and a further reduction of the entomology group? I am happy to answer these questions with NO, on the contrary, we have somewhat increased and we will be allowed to appoint 2 more staff members and 3 technicians in 2001. In this annual report you will be updated on the many achievements in our research and teaching programmes.

Besides our normal research and teaching tasks, we organized the 7th European Workshop on Insect Parasitoids (The Antonie Van Leeuwenhoek Symposium) from 1-6 October in the Teylers Museum, in Haarlem. With more than 100 participants current topics in parasitoid biology were discussed. Part of the papers will be published in special issues of the journal Biological Control.

Wageningen University has changed its education format recently. As of 1 September 2000 we have a three years BSc phase, a two years MSc programme and a four years PhD programme. This results in a complete revision of the teaching programme with a lot of time invested in designing new courses.

Wageningen University and Research Centre, the centre in which three agricultural organizations related to the Ministry of Agriculture collaborate did intensify its activities to stimulate cooperation. All research in plant sciences is now governed by a board of directors of three units: the university, the agricultural research centres and the more applied regional research stations. This collaboration provides an excellent opportunity for our laboratory to strengthen our research in the field of multitrophic interactions, chemical ecology and functional biodiversity.

Joop C. van Lenteren



Tomicus typographus. *Scolytus destructor.*

2. ACTIVITIES

a. General

The research programme of the laboratory of Entomology is interdisciplinary in nature and covers ecological, physiological and molecular biological studies with insects.
The participants collaborate on a daily basis in a range of projects. Fundamental research focuses on the theme 'Carnivore-herbivore-plant interactions'. The results of these fundamental studies are then used to develop or improve host plant resistance, and biological and integrated control programmes for pests and insect vectors of human diseases. Knowledge of the functioning of herbivores and natural enemies in natural- and agricultural ecosystems is elementary for manipulating agro-ecosystems such that sustainable agriculture can be realised. This research is embedded in the graduate schools 'Production Ecology' and 'Experimental Plant Sciences' that have been approved by the Royal Dutch Academy of Sciences. Our teaching programme is embedded in the Life Sciences Teaching Institute.

In 2000 we started with a large project funded by the Dutch Science Foundation on 'Enhanced Biodiversity for Sustainable Crop Protection' in which several groups of Wageningen University and Research Centre, together with scientists of the Institute for Systematics and Population Biology of the University of Amsterdam, are collaborating in the prevention of diseases, weeds and insect pests in biodiverse farming systems. Landscape ecological aspects are also playing a role in this research project. The German Bosch Foundation and the European Union added research grants that are linked to the biodiversity research programme. One of our focal points in the coming five years will be the analysis of biologically poor and rich farming systems in relation to pest prevention and management.

In 2000 we were very successful in obtaining grants, i.e. apart from the above-mentioned programme on Enhanced Biodiversity another three were awarded by the Dutch Science Foundation, one by the Royal Dutch Academy of Sciences and one by the EU.

Our population of PhD students remained stable. Although 6 PhD students finished this year, a cohort of new students kept the total number at about 40. The number of MSc students increased considerably. However, as in previous years, the number of BSc students did decrease. The staff participated in the organization of summerschools and masterclasses at Wageningen University, and taught courses abroad (Europe, Africa and Latin America).

During 2000 the following persons left the laboratory: P. Huisman, T. Hogen Esch, I. Kok, G. Pesch, T. de Vries, F.W.N.M. Vaal, and the PhD students M.J. Bonhof, A. Groot, O. Krips, M. Manzano, P. van Mele, and S. Suetterlin who all finished their project by successfully defending their theses.

The following persons joined our laboratory in 2000: M. Bleeker, A. Bruinis, T. Bukovinsky, Huang Ying, Gilsang Jeong, O. Poitevin, Yutong Qiu, M. Brewer, E. J. Scholte, W. Tinzaara, K. Winkler, Y. Tricault, J. van Vugt, F. Vavre, and F.L. Waeckers.

2. ACTIVITIES

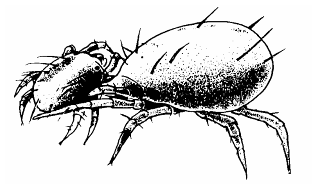
As in other years, many foreign colleagues, groups of students and also non-entomologists found their way to our Laboratory. Of special importance were the visits of a delegation Chinese Academy of Agricultural Sciences, and of the minister of Developmental Collaboration of The Netherlands. We always appreciate visits to our laboratory, as they provide an excellent opportunity to share our interest in insects with many other persons.

The scientific activities resulted in 102 publications and 89 oral presentations .

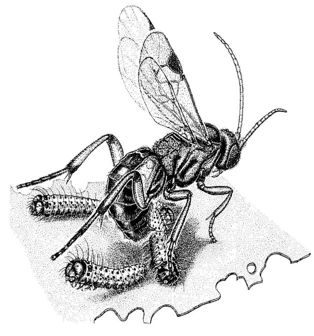
b. Research highlights

I. Plant-carnivore mutualism through chemical information conveyance

- Infestation of lima bean leaves with spider mites results in root exudates that affect neighbouring plants: the receiving neighbour emits volatiles that attract the predatory mite *Phytoseiulus persimilis.* Thus plants may have underground chemical exchange through the soil that is exploited in induced defence. The behavioural response of the predatory mites can be lost by a bacterial infection. The pathogens are being identified.
- For a variety of plant species, headspace analysis of spider-mite infested plants has shown that some species emit novel compounds that are not emitted in response to mechanical damage, while others emit similar compounds in response to herbivory and mechanical damage. Methyl salicylate is reported as a spider-mite induced volatile for many plant species. The presence of this chemical in the headspace is important in attraction of the predatory mite *Phytoseiulus persimilis.*



- In nature, plants are seldomly infested by a single herbivore species. For cassava plants we showed that attraction of *Typhlodromalus* predatory mites to cassava infested with cassava green mite was not affected by simultaneous infestation with cassava red mites, but simultaneous infestation with two spotted spider mites significantly reduced the attraction of the predators.
- Arabidopsis is becoming a model plant for our tritrophic research programme. Damage by a single 1st instar *P. rapae* caterpillar results in the attraction of the parasitoid *Cotesia rubecula*. Attraction of this parasitoid benefits the plant in terms of seed production and thus in terms of Darwinian fitness.
- Detailed observations on the behaviour of the egg parasitoid *Uscana lariophaga* were made to quantify parameters on individual behaviour to be included in a model on parasitoid host finding.



II. Phenotypic plasticity and genetic variation in foraging behaviour of natural

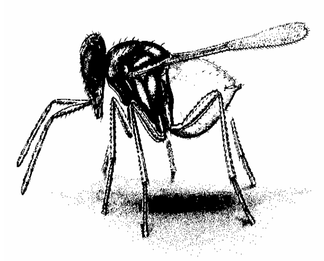
enemies.

- Host-seeking behaviour of malaria mosquitoes is dependent on the time since the last blood meal. Right after a blood meal no mosquitoes respond to the odour of a human hand, but with time the response appears and 72h after the last blood meal all mosquitoes were attracted.

2. ACTIVITIES

III. Optimality, population dynamics and evolutionary stable strategies in parasitoids and predators

- A dynamic state-variable model on host-feeding strategies of *Encarsia formosa* was completed. At average host densities previously found during field research in Costa Rica, the model predicts host feeding to be maladaptive when parasitoids live short, but adaptive when they live long. Field work in 2001 in Costa Rica is aimed at determining life span of *Encarsia formosa*.



IV. Evolutionary ecology of asexuality and sex ratio distortion in insects

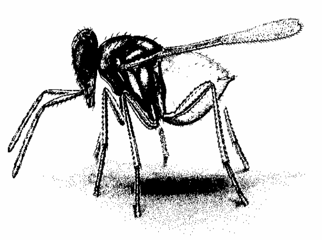
- Field work in California and laboratory work in Wageningen showed that horizontal transfer of Wolbachia was possible in case of multiparasitism of host eggs. But Wolbachia infected parasitoid eggs show a reduced competitive ability when the share a host egg with uninfected parasitoid eggs.

V. Biological and integrated pest/vector management

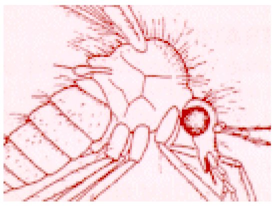
- Distribution patterns of the deser locust, *Schistocerca gregaria*, were determined in relation to habitat factors in the coastal plain of East Sudan. Analysis of the data suggests that vegetation and soil data can be used as indicators for areas where locusts are most likely to be found.
- The foraging behaviour of *Uscana lariophaga*, an egg parasitoid of bruchids, was studied and modelled. Parasitoid dispersal was analysed in large and small containers. The parasitoid shows negative geotaxis. Also, control of bruchids by using plant secondary metabolites as repellents or toxins is studied. Thirty plants traditionally used in Benin (Africa) have been tested; ten of these plants had toxic effects, seven were repellent and five reduced oviposition.
- The results of simulations with the individual based model for the tritrophic relationship Gerbera, whitefly and *Encarsia formosa*, in combination with validation and verification work in greenhouses, showed that whitefly control should be possible, and can be improved by using partially resistant Gerbera cultivars and a somewhat higher greenhouse temperature.
- Field work on the effect of intercropping on pest populations showed that (1) pest populations were lower in the intercrop when compared with the monocrop, a finding which is often mentioned in the literature; however, when the number of pest insects per unit biomass was calculated we found relatively more pest insects in the intercrop (many earlier studies did not correct for plant biomass), (2) also contrary to expectations, we found that

plant quality in the intercrop was better for the pest insects than that in the monocrop.

- Greenhouse work in Colombia and laboratory work in Wageningen on the possibilities for biological control of whitefly on greenhouse tomatoes with *Encarsia formosa* and/or *Amitus fuscipennis* revealed that low greenhouse temperatures may complicate successful control, but with intelligent releases biocontrol will be possible.
- Life histories and foraging behaviour of various parasitoids (e.g. *Encarsia*, *Eretmocerus*, *Amitus*, *Telenomus*) were studied as basis for biological control programmes.

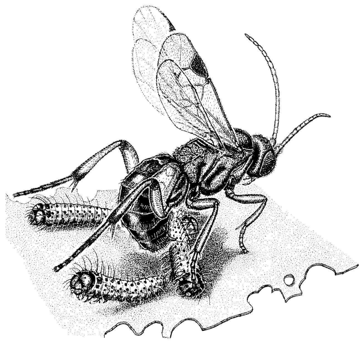


- Field studies on native and exotic whitefly and natural enemy species in natural areas has resulted in qualitative and quantitative data of populations of these species. Overwintering experiments in the field showed that the exotic parasitoid *Encarsia formosa* cannot survive Dutch winters. Further, although hundreds of thousands individuals of these parasitoids are released in greenhouses every year, very few disperse into the field, and parasitization of native whitefly hosts near greenhouses is very rare.
  Field work in Colombia and laboratory work in Wageningen on the relationship between bean, whiteflies and the native Columbian parasitoids *Amitus fuscipennis* and *Encarsia nigricephala* showed that these parasitoids can substantially reduce whitefly populations in the field, but that augmentative releases or habitat management to stimulate development of locally present populations are needed for early control.
- DNA profiles were developed for several parasitoids in order to be able to properly identify closely resembling species (e.g. *Trichogramma, Encarsia*) or to determine the origin of field released material.
- The dynamics of larval populations of *Anopheles spp.* were studied in West Kenya in relation to environmental factors, showing that at the start of the rainy season *A. gambiae* populations increased to the detriment of the sibling species *A. arabiensis*.

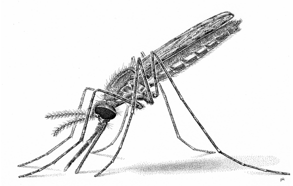


- In a study on feeding patterns of *Anopheles* with a 3-armed olfactometer which is able to host human individuals in each arm, it was found that there are significant differences in attractiveness among humans. Further, there is an interaction between body heat and volatiles.

VI. Sensory physiology in insect-plant interactions



- Through a GC-EAD approach the components of the complex mixture of herbivore-induced volatiles emitted by *Pieris*-infested cabbage plants that are perceived by *Cotesia* parasitoids have been identified. Out of the total of 80+ components 20 evoked consistent EAG responses. The responses of the two parasitoids *Cotesia glomerata* and *C. rubecula* were similar except for the response to one component of the odour blend.
- Using virus-transmission as a reporter, salivation of aphids has been investigated. No unknown periods of salivation were found.
- In thrips a combined EPG – close range video technique was developed to investigate their feeding behaviour.



- **3. TEACHING**

a. General

The teaching obligations of the laboratory comprise Entomology, and Animal Ecology mainly for students in Crop Protection and Plant Breeding (T15) and Biology. Some classes are attended by students from other fields such as Plant Science (Plantenteelt, T16), Animal Production (Zootechniek, T20), Environmental Science (Milieuhygiene, T32) and Molecular Sciences (Moleculaire Wetenschappen, T33). The laboratory offers a wide variety of classes (see figure below). The class Origin and Management of Pests is a basic class for Plant Breeding and Crop Protection (T15) students; from this class they continue to Insect Biology and from then to doing research for their theses. Biology students are stimulated to start with Insect Biology.

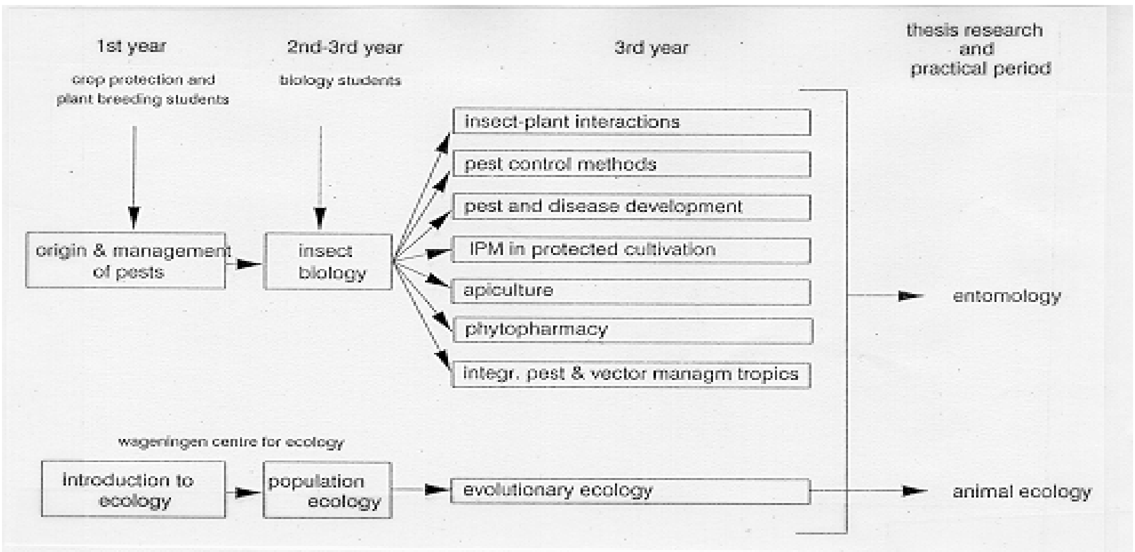


Figure 1: supply of classes

b. 2000

A total of 40 students finished their thesis in Entomology or Animal Ecology under the supervision of staff of the laboratory of Entomology. Distribution of students over fields of study: Biology: 24; Plant Breeding and Crop Protection: 13; Tropical Landuse: 1; Animal Science: 1.

Two students wrote an essay on a subject for “Insects and Society”.

A total of 4 students completed a practical period in the Netherlands or abroad with an exam. Distribution of students over fields of study: Plant Breeding and Crop Protection: 3; Biology: 1;

A total of 6 PhD theses were completed and successfully defended:

• Bonhof, M.J.	The impact of predators on maize stem borers in coastal Kenya.. Promotor: Prof. Dr. J.C. van Lenteren, co-promotor: Dr. Ir. A. van Huis.
• Broek, I.V.F. van de	Olfacory sensitivity of *Anopheles* mosquitoes with different host preferences. Promotors: Prof. dr. B.G.J. Bohus and Prof. dr. J.C. van Lenteren, co-promotor: Dr. C.J. den Otter
• Groot, A.T.	Sexual behaviour of the green capsid bug. Promotor: Prof. Dr. M. Dicke, co-promotor: Dr. J.H. Visser.
• Krips, O.E.	Plant Effects on biological control of spider mites in the ornamental crop Gerbera.. Promotors: Prof. Dr. M. Dicke, Prof. Dr. M.W. Sabelis, Prof. Dr. J.C. van Lenteren.
• Mele, P.L.J. van	Evaluating farmers' knowledge, perceptions and practices: a case study of pest management by fruit farmers in the Mekong Delta, Vietnam. Promotor: dr. J.C. van Lenteren, co-promotor: dr. A. van Huis.
• Sütterlin, S.	Biological control of whitefly on Gerbera: success or failure? Tritrophic interactions between *Gerbera jamesonii, Trialeurodes vaporariorum and Encarsia formosa*. Wageningen Universiteit. Promotor: Prof. Dr. J.C. van Lenteren, co-promotor: Dr.Ir. J.J. Fransen

The following numbers of students participated in the classes:

Origin and management of pests	31
Insect Biology	25
Integrated pest and vector management in the tropics	22
Integrated pest management in protected cultivation	21
Insect Plant Interactions	17
Insects and Society	10
Disease and pest development	18
Pest control methods	13
Apiculture	19
Evolutionary Ecology	25
Problem-oriented approach in Biology	60
Phytopharmacy	18
Molecular Ecology	23
Population Ecology	50

	PhD students (January 2001)	short title (graduate school)	period	promotor/
	Almeida, R.P. de	optimal performance of Trichogramma in biocontrol (PE)	99-03	v. Lenterer
	Ardeh, M.J.	sex determination in Eretmocerus (PE)	01-04	v. Lenterer
3.	Bleeker, M.A.K.	learning in parasitoids: from behaviour to neuron (PE)	00-05	Vet/Smid/v
4.	Boeke, S.J.	use of secondary plant substances to protect cowpea against insects (EPW)	98-02	Dicke/v.Lo
5.	Boer, J.G. de	odour effects on behavioural responses in predatory mites (EPW)	99-03	Dicke
6.	Boom, C.E.M. van de	phytochemical analysis of mite tritrophic interactions(EPW)	97-01	de Groot/I
7.	Bukovinsky, T.	biodiversity and crop protection (PE)	00-04	v. Lenterer
8.	Burger, J.M.S.	host feeding and oviposition by Encarsia formosa (PE)	97-01	v. Lenterer
9.	Burgio, G.	agroecological approaches for aphid control (PE, Bologna)	97-01	v. Lenterer
10.	Charleston, D.S.	biological control, host plant resistance and chemical control of Plutella (EPS)	99-03	Dicke/Vet
11.	Gebremedhim, W.T.	designing strategies for desert locust control(PE)	98-02	v. Lenterer
12.	Giessen, W.A. van	sensory physiol aphids (EPW)	93-01	v. Lenterer
13.	Gilsang Jeong	Wolbachia in egg paratioids (PE)	00-04	v. Lenterer
14.	Gnanvossou, D.	chemical ecology of tritrophic interactions in cassave green mite system (EPW)	98-02	Dicke
15.	Gohole, L.S.	effect of molasses grass on stemborer parasitoids in Keny (PE)	97-01	Vet, v.Huis
16.	Hess, L.	evolutionary ecology of Arabidopsis and other crucifers (EPS)	01-05	Dicke/v. Lo
17.	Huigens, M.E.	genomic conflicts over sex ratios in wasps (PE)	99-03	v. Lenterer
18.	Huang, Y.	risks of importation of exotic organisms (extern, Univ. Beijing)	99-03	v. Lenterer
19.	Hulshof, J.	biocontrol of western flower thrips with predators (PE)	96-00	v. Lenterer
20.	Kindt, F.	feeding behaviour and virus transmission of Frankliniella occcidentalis (EPS)	99-03	Dicke / Tja
21.	Koenraadt, C.J.M.	Population dynamics of Anopheles in West Kenya (PE)	98-03	v. Lenterer
22.	Loomans, A.J.M.	biocontrol thrips (PE)	91-00	v. Lenterer
23.	Masanza, M.	control of banana weevil (PE)	97-01	v. Lenterer
24.	Mukabawa, W.R.	feeding patterns of African malari vectors in nature (PE)	98-02	v. Lenterer
25.	Nomikou, M.	biological control of whitefly with predatory mites (extern, Amsterdam)	97-01	Sabelis/va
26.	Niyibigira, E.I.	genetic variability in Cotesia and biocontrol (PE)	98-02	v. Lenterer
27.	Pates, H.V.	introduction of gene(s) for zoophily into anthropophilic Anopheles gambiae (PE)	98-02	v. Lenterer
28.	Poecke, R. van	signal transduction in herbivore-induced volatile production by plants (EPW	98-02	Dicke
29.	Qiu Yutong	human volatiles as attractants for Anopheles (PE)	00-04	v. Loon/Takk
30.	Sauers-Müller, A.E. van	behaviour of Carambola fruitfly (PE)	94-00	v. Lenterer
31.	Scholte, E.J.	entomopathogenic fungi as bc agents of mosquito's (PE)	01-05	v. Lenterer
32.	Schütte, C.	semiochemicals pred. mite tritrophic (EPW)	92-00	v. Lenterer
33.	Stolk, C.	biocontrol of cowpea with Uscana egg parasitoids (PE)	97-01	v. Lenterer
34.	Tinzaara, W.	semiochemicals for control of banana weevil (EPS)	00-04	Dicke/ v. H
35.	Tommasini, M.G.	evaluation of polyphagous predators for thrips control (PE)	93-00	v. Lenterer
36.	Vis, R. de	biological control of whitefly (PE, Columbia)	97-01	v. Lenterer
37.	Vugt, J. van	working mechanism of sex modifying supernumerary chromosomes (EPS)	00-04	v. Lenterer
38.	Wertheim, B.	drosophila aggretation pheremones as kairomones (FE)	96-00	v. Lenterer
39.	Winkler, K.	field edges, biodiversity and pest prevention (PE)	01-05	v. Lenterer
40.	Xuereb, A.	host recognition of ectoparasitoids of bruchids (PE)	98-00	Vet/v. Lent
41.	Yang Limei	arabidopsis molecular biology Plutella and Cotesia (EPS)	01-05	Dicke/v. Lo
42.	Zijp, J.P.H.	biocontrol/IPM orchard pests (PE)	91-00	v. Lenterer

4. COMMUNICATIONS ON RESEARCH

A. Progress in research projects

Long-term goals
Through both a functional evolutionary ecological approach and a causal analytical approach the following issues
are studied:

1. Dynamics and genetics of insect populations: causes of population fluctuations and ways to manage them.
2. Functioning of multitrophic systems.
3. Insect foraging behaviour.
4. Insect sensory physiology and neurobiology.
5. Co-developing testing and implementation of sustainable pest control methods.

These long-term goals are followed in order to contribute to the establishment of environmentally-safe pest
control for which we need:

- Simulation models which explain and predict host-plant, pest-insect and natural Knowledge on the effects of host-plant resistance on natural enemies and v.v.
- Knowledge on host location by pests, vector insects and their natural enemies.
- Evaluation criteria of the control capacity of natural enemies for different types of biological control of pest and vector insects.

The research projects are grouped around several themes:

I. *Plant-carnivore mutualism through chemical information conveyance*
Projects: Dicke (EPS2d-06), Schütte (EPS2d-04), Schütte (EPS2d-20), Krips (EPS2d-08), Gnanvossou (EPS2d-18), van den Boom (EPS2d-15), de Boer (EPS2d-19), van Poecke (EPS2d-16), van Huis (G050.861), Wäckers (PE33-00b).

II. *Phenotypic plasticity and genetic variation in foraging behaviour of natural enemies*
Projects: Vos (G050.941), Wertheim (FO), Gohole (PE31-98a), Takken (PE &RC 32 00aj).

III. *Optimality, population dynamics and evolutionary stable strategies in parasitoids and predators*.
Projects: van Lenteren (PE32-94a), Burger (PE33-97d), Sütterlin (G050.893), van Roermund(PE32-95a), Qiu (PE32-95g).

IV. *Evolutionary ecology of asexuality and sex ratio distortion in insects*
Projects: Koopmanschap(PE35-98b), Huigens (PE-New), van Vugt, (EPS-new), Vavre (PE-new), Jeong (PE-new).

V. *Biological and integrated pest/vector management.*
Projects: Mols, (PE32-4b), Zijp (G050.913), Loomans (PE32-94h/G050.911), Meekes (PE33-97g/G050.932), Manzano (PE33-97j), de Vis (PE-new), Loomans (PE-new), Hulshof (PE-new), Boff (PE33-87a), Pates (PE&RC 31 11t), Schneider (PE&RC 32 10b), Takken (PE-new), Mukabana (PE32 00at), Stolk (PE32-96c), Boeke (EPS2d-17), Bonhof (PE33-99a), Niyibigira (PE32-99a), Gebremedhin (PE39-97a), de Almeida (PE-new), van Mele (PE-new), Bukovinsky (PE&RC39 99d), Winkler (PE&RC 33 01a), Gonzalez (PE&RC new), Bleeker (PE new), Tinzaara (EPS 2d 024), Charleston (EPS2d-021).

VI. *Sensory physiology in insect-plant interactions.*
Projects: van Loon (EPS2d-05), Tjallingii (EPS2b-28), Kindt (EPS2b-75).

4A. - I. PLANT-CARNIVORE MUTUALISM THROUGH CHEMICAL INFORMATION CONVEYANCE

EPS2d-06. Induction of plant volatiles by herbivory: signal transduction and behavioural modification in a multitrophic context. 1993-2000. M. Dicke, H. Dijkman, J. Thaler & P. Mercke. Graduate School Experimental Plant Sciences. Funded by WU.

Objectives. Plants may defend themselves against herbivores by emission of volatiles that attract carnivorous enemies of the herbivores. This may be induced by herbivore damage, both at the site of herbivory, as well as systemically in undamaged tissue of the damaged plant. Herbivore-induced plant volatiles may affect any organism in the environment, including herbivores and plants. Thus, for a thorough understanding of the effect of herbivore-induced plant volatiles a multitrophic approach is needed.

Questions addressed are: (1) How does the plant recognize herbivory, (2) What signal-transduction pathway is induced, (2) How specific is the response of a plant, (3) What is the effect of the emitted volatiles on enemies of the herbivore, on conspecific and heterospecific herbivores and on conspecific and heterospecific neighbouring plants? (4) Why do some carnivore species respond differently than others? (5) Why do some plants respond differently than others? (6) How can this plant resp. be exploited in pest control?

Progress in 2000. When plants respond to herbivory with the emission of volatiles that attract carnivorous enemies of herbivores, downwind neighbouring plants may intercept the volatiles and induce defence against herbivores. Our research has shown that plants that are damaged by herbivores (two-spotted spider mites) also secrete chemicals into the soil. Neighbouring plants respond to these cues with the emission of volatiles that attract carnivorous mites (*Phytoseiulus persimilis*). Thus, herbivory on above-ground plant tissues results in a change in above-ground interactions with other organisms in the environment (herbivores, carnivores and neighbouring plants) as well as a change in below-ground interactions with neighbouring plants. Whether the belowground cues have an effect on soil-dwelling animals remains unknown.

The information that plants emit in response to herbivory is a complex blend of up to 100 compounds or more. Carnivorous arthropods use a selection of this complex blend during foraging behaviour and whether they respond to details of the blend depends on their foraging history, as was shown for the predatory mite *Phytoseiulus persimilis.*

EPS2d-04. Variation in foraging behaviour of the predatory mite *Phytoseiulus persimilis*. 1992-2000. C. Schütte, M. Dicke and J.C. van Lenteren. Graduate School Experimental Plant Sciences. Funded by WU.

Objectives. For a tritrophic system consisting of Lima bean, a spider mite (*Tetranychus urticae*) and a predatory mite (*Phytoseiulus persimilis*) it has been

shown that the predatory mites are attracted by volatile infochemicals which are produced by the plants upon infestation with spider mites.
A clear discrimination between infested and uninfested plants has been reported consistently for the predatory mite *P.persimilis* during the past 12 years. Usually 80 to 90% of predatory mites choose the odour of infested plants when tested in a Y-tube

olfactometer. However recently a population of our laboratory has lost this ability of discrimination. There is strong evidence that an infection with microorganisms induces this remarkable change in foraging behaviour.

Objectives of the present project are: (1) Infection of well-discriminating predatory mite strains; (2) Disinfection of non-discriminating predatory mite strains; (3) Effect of the microorganism on other fitness parameters of the predatory mite; (4) Identity of the microorganism(s).

Progress in 2000. The project is in the writing stage. A thesis is being completed.

EPS2d-20. A new disease in the predatory mite *Phytoseiulus persimilis*: Pathogen identification, development of a detection method and prevention and cure in mass rearing. 1998-2003. C. Schütte, R. Gols, M. Dicke and R. Stouthamer. Graduate School Experimental Plant Sciences. Funded by STW.

Objectives. Mass production of animals may lead to the development of new unknown diseases in these animals. The predatory mite *Phytoseiulus persimilis* is very effective in controlling spider mites (*Tetranychus urticae*) in several field and greenhouse crops and has been reared successfully in commercial mass production since more than 25 years. However, quality reduction of commercially reared *P. persimils* has been reported during recent years. Since 1994 extensive research has been carried out examining factors responsible for profound quality loss of *P. persimilis* in our laboratory. We showed that the quality loss is a contagious phenomenon. By now the main transmission route has been elucidated and an effective bioassay to monitor infectivity have been developed. With this crucial bioassay we may now: (1) identify the pathogen (2) develop a feasible test for pathogen presence in predatory mites based on molecular techniques and (3) develop efficient strategies for preventing and/or curing the disease in mass production.

Progress in 2000. Two bacterial pathogens isolated from *P. persimilis* have been shown to induce quality loss in this predatory mite species.

We identified both pathogens by using molecular and biochemical methods. The pathogen, which induces the most severe symptoms (called "non-responding syndrome"), represents a new species. Taxonomical description of the new species is under way. Furthermore a detection method based on molecular techniques (PCR of the 16s ribosomal RNA) has been developed and evaluated. This test was applied to check whether the new pathogen is present in other commercial and laboratory populations of *P. persimilis* and other predatory mite species as well. The test was negative for other predatory mite species used in biological control, whereas it was positive for several populations of *P. persimilis* from sources of different countries. These results indicate that the bacterium may be restricted to *P. persimilis* and that it is established in *P. persimilis* populations of several countries.

EPS2d-08. Biological control of spider mites on the ornamental crop Gerbera. Are all cultivars equally suitable ? 1994-2000. O.E. Krips, G.J.Z. Gols, M. Dicke, J.C. van Lenteren, M.W. Sabelis, M.A. Posthumus & T.A. van Beek. Graduate School Experimental Plant Sciences. Funded by STW.

Objectives. Plant resistance to herbivores is often said to have a positive effect on biological control, because the herbivore population level is already low without natural enemies. However it is also possible that toxic compounds that are present in the leaf material or on the leaf surface affect the natural enemies negatively. This research addresses the effect of spider mite resistance in the ornamental crop gerbera on the biological control of spider mites.

In the interaction between spider mites and their natural enemy *Phytoseiulus persimilis* the production of herbivore induced synomones by the host plant plays an important role. As well as many other plant species, gerbera starts producing these volatile compounds after attack by spider mites. Some of these compounds are known to attract predatory mites and seem to be essential in local extermination of the spider mites.

Main objectives of this research are to determine differences between gerbera-cultivars in 1) resistance to spider mites, 2) effect on life-history components of predatory mites and 3) production of herbivore induced synomones.

Progress in 2000. The project has been completed and a PhD-thesis has been successfully defended in April 2000.

EPS2d-18. 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. Graduate School EPS. Funded: IITA Benin.

Objectives. Plants that are infested with herbivores emit volatiles that attract natural enemies of herbivores. Furthermor e, in response to carnivore attack, herbivores may emit volatiles that affect the behaviour of the herbivores as well as their carnivorous enemies. These infochemicals affect the distributions and interactions among plants, herbivores and their predators in tritrophic systems. The cassava green mite is an important pest in cassava in Africa. It has been introduced from South America in the 1970s and in the past 25 years many efforts have been made to find effective biological control agents. Recently two promising predatory mites have been found that have very different ecologies: *Typhlodromalus manihoti* and *T. aripo*. The predators differ in distribution over the plant (on leaves or in apex) and in prey range. These differences result in differences in predator response to varying densities of cassava green mites. In this project we will study how induced plant volatiles affect carnivore movement among plants (carnivore attraction to plants infested with different prey species). Special emphasis will be on the specificity of plant volatiles. Furthermore, the effect of volatiles that originate from herbivore-carnivore interactions on carnivore distribution over the plant and interactions among the carnivore species will be studied.

Progress in 2000. Females of *T. manihoti* and *T. aripo* were attracted by cassava odors
induced by *M. tanajoa*. In nature, a complex of herbivores on single plant species is common. In addition to the key prey species *M. tanajoa*, two alternative prey mite species, *Oligonychus gossypii* and *Tetranychus urticae* also occur in the cassava agroecosystem in Africa. We showed that the attraction to prey-induced cassava odors by *T. manihoti* and *T. aripo* did not change when the true prey, *M. tanajoa* and the alternative prey, *O. gossypii*, was offered simultaneously. *Typhlodromalus manihoti* and *T. aripo* still preferred odors induced by the cassava green mite, *M. tanajoa,* to those induced by the cassava red mite, *O. gossypii*, even when twice as many individuals of the latter species were offered compared to those of *M. tanajoa*. Also, the presence of *O. gossypii* interacting either simultaneously on the same leaves or on different sets of leaves with *M. tanajoa* did not alter the response of the two predators in detecting odors from *M. tanajoa*-infested leaves. This could lead to apparent competition when predators are in the prey patch. In contrast, odors from *T. urticae*-infested leaves interacting with those from *M. tanajoa*-infested leaves hampered *T. aripo* and *T. manihoti* in detecting specific odors from *M. tanajoa*-infested leaves leading to an infochemically-mediated form of enemy-free space.

EPS2d-15. Indirect defense of plants: variation among plant species and determination of the bioactivity and chemical nature of the plant volatiles involved. 1997-2001. C.E.M. van den Boom, T.A. van Beek, M. Dicke & A.E. de Groot. Graduate School Experimental Plant Sciences. Funded by WU.

Objectives. Plants can defend themselves against herbivores in two ways: a) directly through e.g. toxins and digestibility reducers, and b) indirectly through attraction of carnivorous enemies of the herbivores. This project investigates the correlation between direct and indirect defense. Is there a negative correlation between the degree of direct and indirect defense? This will be studied for species in the plant families Fabaceae and Solanaceae, with the generalist herbivore *Tetranychus urticae* and its specialist predator *Phytoseiulus persimilis*. With respect to indirect defense the study will concentrate on herbivore-induced plant volatiles with an emphasis on attraction of predatory mites, chemical analysis of the emitted volatiles and development of a method to reconstitute plant volatile mixtures for investigation of predator responses in behavioural studies.

Progress in 2000. Volatiles induced by two-spotted spider mites in a range of plant species have been investigated with respect to attraction of the predatory mite *P. persimilis* and the chemical composition. All plant species investigated attracted the predators. The volatiles induced vary with plant species. In some species many novel compounds are induced in others few or no novel compounds are induced.

EPS2d-19. 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), Graduate school EPS, Funded by ALW.

Objectives. Plants that are infested with herbivorous arthropods emit complex odour blends that can comprise up to 200 different components. Carnivorous arthropods exploit these odours to locate their herbivorous prey. Very little knowledge is available on the blend components that are important in evoking a behavioural response and that enable carnivores to discriminate among blends. Qualitative vs. quantitative differences and major vs. minor components of the blend may be important. Experimentally manipulated odour sources will be used to investigate the role of quantitative and qualitative variation in odour blends on the behavioural responses of predatory mites.

Progress in 2000. One of the components of the volatile blend emitted by spider mite infested Lima bean plants is methyl salicylate (MeSA). Experiments confirmed that MeSA is an important component of the total volatile blend for the attraction of *Phytoseiulus persimilis*. MeSA is attractive as a single compound dependent on the quantity that was offered.

The amount of MeSA in the blend is of less importance, *P. persimilis* only avoids spider mite infested Lima bean leaves when a large (repellent) amount of MeSA was added. MeSA increased the attractivity of jasmonic acid induced Lima bean odours from 30 % to 70 % when tested against *Tetranychus urticae* induced Lima bean. Furthermore starvation period and rearing history (experience) of *P. persimilis* influence their response to MeSA.

EPS2d-16 . Signal transduction in herbivore-induced production of volatiles by plants: *Arabidopsis-Pieris-Cotesia* interactions. 1998-2002. R.M.P. van Poecke & M. Dicke. Graduate School Experimental Plant Sciences. Funded by WU.

Objectives. To find their herbivorous host, parastoid wasps like *Cotesia rubecula* use volatile cues emitted by plants infested with these herbivores. The volatile blend emitted by infested plants can differ from the blends of uninfested or artificially damaged plants. Signal transduction involved in the induced volatile production of plants has been studied since a few years. Application of regurgitant of *Pieris* caterpillars or one component thereof, ß-glucosidase, onto mechanically damaged cabbage leaves results in a volatile blend similar to that of herbivore infested plants. Little is known of the signal-transduction in response to caterpillar feeding or regurgitant application.

The main aim of this project is to further elucidate the signal transduction pathway in *Arabidopsis thaliana* in response to *Pieris rapae* feeding. From this model plant, many mutant or transgenic plants are available that are altered in potential signal transduction pathways. In combination with plant hormone treatment and artificial or (real or simulated) *P. rapae* damage, these mutant or transgenic plants will be used to increase our knowledge on the signal transduction pathway.

Volatile emissions will be monitored by 1) behavioural analysis of the parasitoids in a windtunnel, 2) identification of the volatiles using GC-MS, and 3) expression studies of genes involved in volatile production.

Progress in 2000. "No choice" windtunnel experiments were carried out using a single Arabidopsis plant infested with a single 1st instar *P. rapae* caterpillar. The parasitoid *C. rubecula* showed increased attraction towards the plant after 3 days of infestation. "Dual choice" windtunnel experiments with several mutant/transgenic Arabidopsis plants demonstrated the involvement of several plant hormones in indirect defenses. Detailed studies on herbivory-induce gene-expression were continued.

PE33-00b (G050.861). Control of *Callosobruchus maculatus* and *Bruchidius atrolineatus* (Col.: Bruchidae), insects in storage or cowpea (*Vigna unguiculta*) by the egg parasitoid *Uscana* sp. (Hym.: Trichogrammatidae). 1986-2000. A. van Huis, C. Stolk and G.J.K. Pesch. Graduate School Prod. Ecology. Funded by WU.

Objectives. The stored-product pests, *Callosobruchus maculatus* (F.) and *Bruchidius atrolineatus* Pic. (Coleoptera: Bruchidae) cause considerable production losses in cowpea in West Africa. As chemical control of bruchids in traditional granaries is not appropriate for poor farmers, enhancement of the efficacy of the parasitoid by environmental manipulation is investigated. The research is carried out in collaboration with the Sahelian Training Department of Crop Protection (DFPV) and the University of Niamey, both in Niger, and the University of Tours in France. Our laboratory concentrates on the trichogrammatid *Uscana lariophaga*, a parasitoid of bruchid eggs in the field as well as in storage.

Progress in 2000. The spatial oviposition data of *Callosobruchus maculatus* were further analysed to show what the consequences are of *Callosobruchus* egg distribution for *Uscana lariophaga*. The foraging behaviour of *Uscana lariophaga* was studied in great detail in an experimental arena with one layer of cowpea seeds. Both location and behaviour of the parasitoid were recorded simultaneously. These data will be used in the construction of a model which describes the foraging behaviour of *Uscana lariophaga*. We continued with experiments in which we measured the dispersal ability of *Uscana lariophaga* in stored cowpea. We did so in both large and small experimental storage containers. In the large containers, we investigated the effect that the distance between the release point of *Uscana* and the host patch has on the probability that the host patch was found, and on the number of parasitized eggs.

In the small containers we investigated the effect of distance, foraging time interval, and orientation (upward, downward, and horizontal). Both foraging time and distance appeared to have a significant effect on host finding probability and on the number of parasitized eggs, but the effect of time was more important than the effect of distance. *Uscana lariophaga* also showed a negative geotaxic response.

PE-new. Extrafloral nectar in a tri-trophic context. 2000-2003. F.L. Wäckers. Graduate School PE&RC. Funded by KNAW.

Objectives: The proposed project aims to elucidate the role of extrafloral nectar in indirect defense and to identify strategies by which plants optimize the use of this (costly) resource. The following questions are addressed: 1. Costs and benefits of extrafloral nectar production. 2. Mechanism of induction of nectar production and 3. Gustatory response of parasitic Hymenoptera to nectar and honeydew sugars. *Gossypium* spp. have been chosen as a model plant for these studies as cotton plants possess a range of extrafloral nectaries on vegetative and reproductive structures. In addition, *Gossypium* spp. have been widely studied with respect to other (inducible) direct and indirect defenses, allowing comparisons between various putative defenses.

Progress in 2000: To study costs and benefits of extrafloral nectar production, seeds from near isogenic lines (either nectar producing or nectariless) were obtained. To address ecological costs and benefits of indirect defense in cotton, a field experiment was initiated in collaboration with the Universidad Autonoma de Yucatan, Mexico. This will allow us to study extrafloral nectar mediated interactions of wild cotton (*Gossypium hirsutum*) in its natural habitat. To study mechanisms of nectar induction, bractal nectar production of *Gossypium herbaceum* was studied relative to its phenology. In part of the plants, bracts were exposed to herbivore (*Spodoptera littoralis*) feeding. This to determine whether nectar secretion by bractal nectaries is inducible.

4A. - II. PHENOTYPIC PLASTICITY AND GENETIC VARIATION.

FO-1a (G050.941). Adaptation of parasitoid foraging strategies to the spatial distribution of host species. 1995-2000. M. Vos, L.E.M. Vet & L. Hemerik. Research School Functional Ecology. Funded by WU.

Objectives. We compare the foraging strategies of two species of *Cotesia* parasitoids that attack caterpillar host species that markedly differ in their spatial distributions (clumped vs. uniform). The aim is to evaluate whether *Cotesia glomerata* has adapted to a host with a clumped distribution and *Cotesia rubecula* to a host with a uniform distribution. Using modelling in combination with experimental analysis we aim to:

1) infer adaptive var. in the way parasitoids deal with diff. in spatial host distribution.

2) determine whether variation in the foraging strategy has a genetic basis or is affected by differing environmental factors.

3) assess how this variation can be best exploited to improve biological control.

Progress in 2000. A thesis has been completed which will be defended in 2001.

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. Graduate School Production Ecology & Resource Conservation. Funded by ALW.

Objectives. Drosophilid flies produce volatile aggregation pheromones which attract flies of both sexes. The aggregated adult flies both feed, mate and oviposit on the aggregation site and as a result the larvae too have an aggregated distribution among breeding substrates. This aggregation behavior is evaluated in terms of costs and
benefits to the flies' fitness. Previously, it was shown that *Leptopilina*, a larval parasitoid of *Drosophila*, exploits the aggregation pheromones while foraging for host larvae. That could result in an increased rate of parasitism. In this project, the costs of aggregation pheromone production is assessed in terms of offspring loss through parazitation. Furthermore, the effect of the aggregation phermone on competition in the larval stage will be investigated. The benefits of the pheomone will be studies by looking at its function in mate selection and resource exploitation.

Progress in 2000. This project is in the writing stage. A thesis is close to completion. The main conclusions are given below. Aggregation pheromones play an intricate role within a food web context, and a variety of costs and benefits arise through their direct and indirect influences on ecological interactions. The costs and benefits for the use of aggregation pheromone are different for male and female fruit flies and depend largely on the characteristics of the evironment. Both aggregative distributions and information webs can fundamentally alter population dynamics in a food web context. Therefore, it is essential to achieve a better insight on the causal mechanisms of aggregative behaviour, the function of this behaviour for the individual and the ecological implications for food web interactions. Such a rigorous integration will not only significantly improve our understanding on the dynamics within ecological systems, but also stimulate the recognition that population dynamics rely heavily on spatio-temporal variability and the behaviours of individuals.

PE31-98a. Effects of molasses grass (*Melinis minutiflora)* on the foraging behaviour and searching efficiency of cereal stemborer parasitoids in cereal based cropping systems. 1997-2001. L.S. Gohole, L.E.M. Vet, Z.R. Khan and W.A. Overholt. Graduate School Production Ecology & Resource Conservation. Funded by the Dutch Government.

Objectives. The Natural Enemies Theory of Root (1973) will be evaluated by testing the hypothesis that in an intercrop of sorghum and molasses grass, there are higher parasitism levels in the stemborer *Chilo partellus* than in the monocrop. In addition we aim to evaluate the underlying mechanisms that lead to more parasitoids in the intercrop system. For this we will investigate the influence of the intercrop on parasitoid presence, activity and efficacy in field, semi-field and laboratory set-ups. Specific objectives are: (i) Determine composition and abundance of stemborer parasitoids in a sorghum-molasses grass intercrop and a sorghum monocrop and investigate parasitoid infestation levels in the stemborer C. *partellus* in these fields. (ii) Investigate the searching behaviour and efficiency of parasitoids In an intercrop as compared to a semi-field experiments. (iii) Compare and investigate the effects of molasses grass and sorghum volatiles on the olfactory responses of the selected parasitoids. (iv) Study the headspace composition of infested, uninfested host plants and molasses grass volatile compounds. (v) Compare sorghum grain yields from sorghum monocrop and sorghum-molasses grass Intercrop plots naturally infested by C. *partellus.*

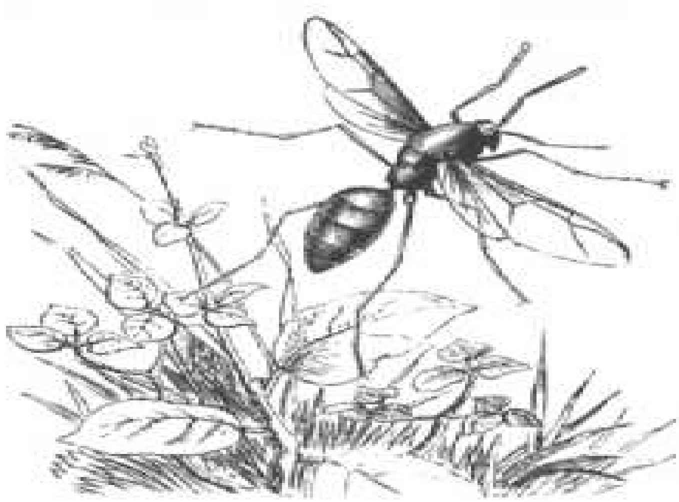
Progress in 2000. Field experiments in which stemborer and parasitoid species composition, abundance and parasitism levels of stemborers in monocrop and intercrop plots were investigated, are complete. Olfactometer bioassays were done to investigate behavioural responses of *C. sesamiae* to molasses grass, sorghum and maize volatiles. Volatiles were collected from molasses grass, sorghum and maize and GC runs done. The work is nearing completion and GC-MS runs will be done to identify the compounds found in the volatiles.

PE&RC 32 00aj (G050.886) - Factors that affect host searching by anopheline mosquitoes. 1989-2005. W. Takken, R. Geene & P.W.T. Huisman. Graduate School Production Ecology & Resource Conservation. Funded by WU and Ministry of Roads, Transport and Public Works

Objectives. Mosquitoes find their vertebrate hosts by use of physical, visual and chemical cues. Little is known about the actual stimuli involved and in which order of importance these are being used. In this long-term research project the role of host derived stimuli to which mosquitoes respond is investigated, with special emphasis on semiochemicals. It is expected that through a better understanding of host seeking behaviour, new methods of mosquito control can be developed by intervening in the host seeking process.

Progress in 2000. The effect of blood ingestion on host seeking activity in *Anopheles gambiae* was investigated. For this purpose mosquitoes were reared of one class size to obtain large sized mosquitoes that require one blood meal only for egg production. Blood fed females expressed a complete inhibition of host seeking during the first 24 hr after blood ingestion. At 48 hr 27% responded to a human hand, and at 72 hr all mosquitoes responded to the host cues. Of the latter, females that had recently oviposited or carried mature eggs responded to the cues. Behavioural studies were matched by studies on the EAG activity after stimulation with 4 different stimuli.

During the first 24 hr after blood feeding there was no EAG effect compared to unfed controls, but at 48 hr EAG responses were inhibited after stimulation with incubated human sweat or indole. During the summer an ecological study on the distribution and species composition of *Anopheles maculipennis* spp. in the delta of the rivers Rhine and Meuse was continued as a follow up of the work started in 1999. This time the proportion of sites carrying larvae of *An. maculipennis* had increased compared to 1999. Also, the proportion of sites carrying *An. atroparvus* had doubled.



4A. - III. OPTIMALITY, POPULATION DYNAMICS AND EVOLUTIONARY STABLE STRATEGIES IN PARASITOIDS AND PREDATORS.

PE32-94a: Understanding biological control of whiteflies by natural enemies. 1983-2006. J.C. van Lenteren, Y. Qiu, J. Burger, Y. Tricault. Graduate School Production Ecology and Resource Conservation. Funded by WU, NWO-ALW, French research organization

Objectives. To unravel the relationships between host-plants, whiteflies (*Trialeurodes vaporariorum* and *Bemisia tabaci*) and their natural enemies. In this long-term programme population dynamics and behavioural ecological aspects of pest and natural enemies are studied. With an understanding of the working mechanism of biological control we will be able to improve control and to develop criteria for evaluation of potential biocontrol agents.

Progress in 2000: The project concerning evaluation of natural enemies of *Bemisia* was concluded. The subproject on whiterfly densities in its natural environment (Costa Rica) revealed important information for development of *Encarsia formosa* foraging strategies. A new subproject was started on individual based simulation modelling of *Encarsia formosa* performance in artificial and natural situations.

PE32-97d. To feed or to reproduce, that's the question: an analysis of foraging decisions in the parasitoid *Encarsia formosa.* 1997-2001. J. Burger, L.E.M. Vet & J.C. van Lenteren. Graduate School Production Ecology & Resource Conservation. Funded by WU.

Objectives. Host-feeding is the consumption of host haemolymph or body tissues by an adult female parasitoid. It provides nutrients that allow the parasitoid to mature additional eggs and to increase longevity. On the other hand, host-feeding is usually destructive in a sense that it kills the host. Thus, host-feeding yields major benefits (increased fecundity and longevity) but also leads to a clear cost (loss of reproductive opportunity). Encountering a host therefore faces the parasitoid with a reproductive trade-off: she has to decide between current reproduction through oviposition and future reproduction through host-feeding. The research focuses on the evolution of host-feeding behaviour by *Encarsia* parasitoids.

Progress in 2000. A dynamic state-variable model on host-feeding strategies was completed, including backward iteration and Monte Carlo simulation. Effects of host density, parasitoid longevity and handling time were investigated. At average host densities previously described from the field, host-feeding was predicted to be maladaptive when parasitoids had a short life expectancy. When life expectancy was long, however, parasitoids were predicted to host-feed. Data on natural longevity of parasitoids are crucially lacking. Host density was the main factor determining whether parasitoids became egg or time limited. Incorporating the fact that host-feeding takes about three times as long

as ovipositorial rejection and oviposition resulted in a dramatic shift from host-feeding to rejection, but only at pest densities.
Furthermore, since we previously showed that feeding on honeydew seemed a good alternative to host-feeding, more lab experiments were carried out.

Increasing the time between host-feeding and dissection from 20 to 48 hours did not change the results qualitatively. Again, parasitoids allowed to host-feed did not have higher egg loads than ones prevented from host-feeding, whereas parasitoids with access to honeydew did have higher egg loads than ones deprived from honeydew. In a next experiment each parasitoid was offered *ad libitum* honeydew and one host-feeding opportunity per day for five consecutive days instead of one day only. In this set-up, parasitoids allowed to host-feed laid about 1.6 eggs per day more than ones prevented from host-feeding. Thus, destructive host-feeding could be adaptive, especially at higher host densities.

G050.893. Biological control of pests in greenhouse ornamentals, especially whiteflies in Gerbera. 1989-2000. S. Sütterlin, J.C. van Lenteren & J.J. Fransen. Graduate School Production Ecology. Funded by Ministry of Agriculture.

Objectives. It is only recently that attempts for biological control of insect pests of ornamentals have started. The main limitation is the almost zero tolerance for insects or signals of their previous presence. In such a situation biological control is difficult. The research concentrates on the role of the degree of hairiness, host-plant architecture and encounter probability in the success of biological control. Finally experiments on greenhouse scale will be done to obtain information under which conditions biological control of whiteflies on gerbera will work.

Progress in 2000: The individual based model earlier developed for the relationship
host plant (tomato), host (*Trialeurodes vaporariorum*) and parasitoid (*Encarsia formosa*) was adapted for the host plant *Gerbera*, which has an architecture which differs a lot from tomato. Simulation results showed that it is mainly the low temperature in Gerbera greenhouses which caused failures of biological control. In addition to a small increase in temperature, also the use of partly resistant Gerbera cultivars may help to improve biological control. The project was concluded with the PhD thesis of S. Sütterlin.

PE32-95g. Development of criteria for the selection of natural enemies: case study of parasitoids of *Bemisia tabaci*. 1995-2000. Y.T. Qiu, J.C. van Lenteren, Graduate School Prod. Ecology & Resource Conservation. Funded by STW.

Objectives. The first step in the selection of natural enemies for biological control is an evaluation based on qualitative parameters: seasonal synchronization with host; internal synchronization with host; climatic adaptation; no negative effects such as hyperparasitization; easy to rear. The second step is to rank these species with respect to their efficiency to depress the host and when inoculative control is intended to maintain the host below the economic threshold level. The following quantitative parameters will be measured for different parasitoid species: 1) high population growth compared to the host; 2) high host-searching efficiency at low host-density, i.e. long distance location of the host; 3) female biased sex-ratio; 4) high fecundity and longevity. Furthermore, the effect at population level will be evaluated with a simulation model developed in our laboratory.

The host studied is *Bemisia tabaci/argentifolii*, an important pest of many crops in warmer regions and of glasshouse crops in the Netherlands. Five parasitoid species have been selected ranging in their expected efficiency based on present knowledge.

Progress in 2000: Work in this project has been concluded. Individual based simulation modelling work currently in progress will indicate which of the five natural enemies will be best for control of *Bemisia*.

PE32-95a. Strategies for sustainable biological control of whitefly: the population dynamics of whitefly and its natural enemies at different greenhouse climates. 1995-1999. H.J.W. van Roermund, J.C. van Lenteren, S. Sutterlin, Y. Tricault. Graduate School Production Ecology. Funded by PE-LNV.

Objectives. Biological control of greenhouse whitefly with the parasitoid *Encarsia formosa* has been applied with great commercial success during the past 20 years, while natural enemies for sweet potato whitefly are now evaluated. Modelling has always played an important role in the process of selecting and improving the efficacy of releases of natural enemies, but often biologically unrealistic simplifications were part of these models which strongly limited their predictive value. A model was developed which is unique in that it is individual based and simulates the local searching and parasitization behaviour of individual parasitoids in a whitefly-infested crop. The model includes stochasticity and spatial structure based on location coordinates of plants and leaves. The model will allow us (1) to explain why the parasitoid can control

whiteflies on some crops and not on others in commercial greenhouses, (2) to improve introduction schemes of parasitoids for crops where control was difficult, and (3) to predict effects of changes in cropping practices on the reliability of biological control, and finally (4) to develop criteria for the selection of natural enemies.

Progress in 2000. Work on the individual based model was taken up again. The model was essential for understanding biocontrol of whitefly in Gerbera (see project Sütterlin) and is now adapted to different foraging situations for various parasitoids.

4A. - IV. EVOLUTIONARY ECOLOGY OF ASEXUALITY AND SEX RATIO DISTORTION IN INSECTS.

PE35-98b. Genetics and epigenetics of sexual and asexual reproduction in Hymenoptera. 1991-1999. A.B. Koopmanschap, H. van Heest, R. Stouthamer. Graduate School Production Ecology, Funded by WU.

Objectives. Completely parthenogenetic reproduction (thelytoky) in Hymenoptera is in many cases caused by a microbial infection. The goal of this project is to study the interaction between the symbiont and its wasp host, and ultimately to be able to manipulate the wasps mode of reproduction from bisexual to parthenogenetic. Parthenogenetic reproduction has several potential advantages over normal bisexual reproduction when wasps are used in biological control.

There are at least two different sex-determination mechanisms in Hymenoptera: a single locus multiple allele mechanisms and another system in which the sex of an individual is determined only by their ploidy level. Species with the first mechanism produce a high fraction of diploid males when the diversity at the sex-allele is low. Such conditions are expected when wasps are mass-reared and will severely impede the biological control potential of such populations. The goal of this research is to design mass-rearing methods that minimize the negative effects of this sex-determination mechanism for biological control.

Progress in 2000. PSR cytogenetics has been characterized. Additional modelling of the interaction between Wolbachia and the host has been done, particularly in the phase of transition from mixed populations of infected and uninfected individuals to completely infected populations.

EPS-4a-22. Mode of action of sex-modifying supernumerary chromosomes, 2000-2004. J. van Vugt, H. de Jong (Genetics, WU), R. Stouthamer and L. Beukeboom (UL). Graduate School Experimental Plant Sciences. Funded by NWO-ALW.

Objectives. The PSR chromosome of *T. kaykai* causes eggs fertilized with PSR carrying sperm to develop into males again carriers of the PSR chromosome. The PSR is a B-chromosome that somehow causes a destruction of the paternal chromosomes in the early fertilization event. The PSR of *T. kaykiai* is only the second known PSR chromosome and the goal of this study is to determine both its mode of action and its origin. The mode of action will be studied by combining cytogenetics and sequencing of the PSR chromosome. The origin of the chromosome will be studied by comparing repeat and (retro)transposon sequences of the PSR chromosome with those of the only known other PSR chromosome of *Nasonia vitripennis* and the A-chromosomes of *T. kaykai* and other species.

Progress in 2000. We used various staining techniques to observe the early events in eggs fertilized with PSR sperm. The cytogenetic mechanism observed was very similar to that of the PSR in *Nasonia vitripennis*.

PE-new. Genomic conflicts over sex ratios in Trichogramma wasps 1999-2003. M. E. Huigens & R. Stouthamer. Graduate School Production Ecology. Funded by ALW.

Objectives. Selfish genetic elements have been defined as elements that will spread through populations despite the costs they may inflict on their hosts. Selfish sex ratio distorters often favor their own transmission by manipulating the sex ratio of the offspring of their host. This causes a genomic conflict between the nuclear genes of the host and the selfish genetic elements. Our research focuses on the genomic conflicts that are present in a wasp species, the egg parasitoid *Trichogramma kaykai*, where two sex ratio distorters are found: 1) a cytoplasmically inherited bacterium (*Wolbachia*), known from about 10% of the females in the population, that causes infected females to produce only daughters and 2) a paternally inherited psr-factor occurs in about 10% of the males in a population, that forces females inseminated by psr-males to produce only male offspring from fertilized eggs. The following questions are addressed: (a) How does the mating structure of the populations affect the frequency of both the *Wolbachia* infection and the psr-like element? (b) Which modes of transmission of *Wolbachia* and the psr-like element exist and what implication does that have on the dynamics and evolution on the population level? (c) Which specific adaptations have evolved from the genomic conflicts and does the host suffer severe fitness costs?

Progress in 2000. This year the focus was on the *Wolbachia*-host association. In *T. Kaykai*, we tested some life history parameters with infected and uninfected females that might be important for host fitness in the field. During the field work in the Mojave Desert (California) from 31 March – 31 July infected wasps are found to produce half the number of offspring produced by uninfected females. In the same experimental set up as in the experiments where we found horizontal transfer of *Wolbachia* inside a host egg last year, we also found a reduced competitive ability of infected eggs when they share a host egg with uninfected eggs. The *psr* chromosome, that is known to keep infection frequencies at low levels in *T. kaykai*, we cannot find in *T. deion*. In this latter related species the infection rate is about the same as in *T. kaykai* and the *psr* factor we can easily transmit in the laboratory from *T. kaykai* to *T. deion*. Therefore you expect the *psr* factor to be present in *T. deion* as well. However we cannot find it in this species, the chance of not finding it in all collected *T. deion* broods collected was 0.005, assuming the same *psr* rates (± 10% of the males) as in *T. kaykai*. Therefore we expect either a different mating structure in *T. deion* or other *Wolbachia* suppressing elements in this species. This will be the focus of future study.

PE-new. Wolbachia genome project 2000-2003. F.Vavre and R. Stouthamer. Graduate School Production Ecology and Resource Conservation. Funded by the European Union.

Objectives. The goal of this European project is to determine the DNA sequence of several *Wolbachia* strains involved with causing various reproductive anomalies in
insects. Wolbachia genomes that will be sequenced include: one causing cytoplasmic incompatibility in *Drosophila simulans*, one causing feminization of genetic males in woodlice and one causing parthenogenesis in the parasitoid wasp *Muscidifurax uninraptor*. Genes responsible for these traits will be identified. This may enable us to use Wolbachia as a method for modifying traits of their hosts.

Progress in 2000. The project has just started, we have boosted up a colony of *M. uniraptor* which is used for the purification of *Wolbachia* DNA for the library that will be used for sequencing.

PE-new. Genetics and physiology of *Wolbachia*-host interactions in *Telenomus nawai* populations: their implications on the reproduction and behavior of *Telenomus nawai*. Gilsang Jeong & R. Stouthamer. Graduate School Production Ecology and Resource Conservation.

Objectives. The wasp species *Telenomus nawai* consists of two forms, a form infected with parthenogenesis *Wolbachia* originating form the island Okinawa and a sexual form originating from Tsukuba, Ibaraki Pref. These wasps are conspecific and in cured males of the parthenogenetic line are capable of mating and fathering offspring with the sexual females. In contrast the parthenogenetic females are unwilling to mate with any male. The relationship between the *Wolbachia* infection and the mating unwillingness is studied as well as many other aspects of the *Wolbachia* infection. The main goal of this study is to extend our knowledge of the evolution of the interaction between Wolbachia and their host.

Progress in 2000. Wasp colonies have been established. Initial studies using antibiotics have been performed. Studies on basic life-history studies have been finished.

4A. - V. BIOLOGICAL AND INTEGRATED PEST/VECTOR MANAGEMENT.

PE&RC 39 99d Enhanced biodiversity of arthropod natural enemies for sustainable control of herbivores. 2000 – 2004. T. Bukovinsky, J.C. van Lenteren & L.E.M. Vet.
Graduate School Production Ecology & Resource Conservation. Funded by ALW

Objectives. Increase of foral diversity does not inherently decrease pest problems and experimental data support a lack of general understanding on the functioning of bio-diverse ecosystems. Our general objective is to identify pest-regulating processes in a specific intercropping system and to reveal their directions in order to establish a higher degree of diversity with a great functional value. In our project two different habitat management strategies (intercropping and field edges) are compared to monocultures, in large plot experiments at two sites in the vicinity of Wageningen. An intercropped system of a dicot (Brussels sprouts) and a monocot (brewers` barley) species has been established, using an additive design.

Progress in 2000. Monitoring of pest populations on Brussels sprouts revealed that populations were decreased in intercroped stands. However, these lower population levels exhibited greater pressure in intercropped stands than in monotypic stands. Besides, Brussels sprout plants in the biculture stands supported a faster development of *Pieris brassicae* although did not influence pupal and adult weights differently than
monocropped plants. Larvae on intercropped plants required more leaf material to finish their development than those on plants from monotypic stands. This suggested that the confounded effects of plant density and diversity acting differently in the two systems make a complex evaluation of the system necessary. Differences in activity of *Plutella xylostella* and those parasitoid species that are specialised in crucifer habitats showed very similar patterns. Differences in their densities have been detected in a small scale (even within intercropped stands).

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.
Graduate School Production Ecology & Resource Conservation. Funded by Robert Bosch Foundation

Objectives. Establishing flowering field margins as part of a biological control approach to boost natural enemies is currently much debated. Often, only the possitive aspects of field margins are stressed and the composition of margins (annual/perennial, plant species, architecture) is not critically designed. Above described results stress the importance of - as well as the potentials for - strategic use of floral resources to boost biological control. In this study we want to investigate how 1) the use and 2) the composition of field margins can be designed to maximally benefit the needs of natural enemies, in order to boost their populations to prevent herbivore damage in crops.

Within the multitrophic system 'crop - herbivore - natural enemy' we aim at identifying of flowering plant species which selectively fullfill the needs of predators and parasitoids of selected key pests without supporting pest organisms. Depending on the characteristics of the plants (annual or perennial, time of flowering, climatic demands, plant architecture, nectar/pollen availability and quality, refuge) these selected species can be integrated in field boundaries to maintain natural enemy populations and/or sown in strips through the crop to fascilitate colonisation of the field.

Progress in 2000. Field margins were designed near Brussels sprouts field and composition of herbivores and natural enemies was studied in temporary and permanent field edges during the 2000 season. Also dispersal of natural enemies from the field edges into crops was monitored. Functional groups of natural enemies will be selected for specific studies of nectar and pollen use in 2001.

PE&RC new. The role of the natural enemies in reducing whitefly populations in Panama. G.I. Gonzalez, J.C. van Lenteren. 1999 – 2003. Graduate School Production Ecology & Resource Conservation. Funded by Senacyt, Panama Research Organization.

Objectives. The objective is to develop sustainable safe and effective control strategies for whitefly attacking tomatoes in Panama under protected cultivation. The general approach is to study and exploit the biological control potential of the naturally present parasitoids in Panama. Successful completion of this objective could provide an effective alternative for chemical control to Panamanese farmers and sharply reduce the current heavy use of expensive and toxic chemical insecticides. Moreover, the results will be broadly applicable in view of the importance and wide distribution of this insect pest throughout Central America.

Progress in 2000. Experience in molecular biology was gained in order to be able to develop a system for identification of Panaman whiteflies and parasitoids through DNA fingerprinting. DNA profiles were developed for several parasitoids.

PE32-4b. The role of predators and parasites in the control of aphids in apple orchards. 1987-1999. P.J.M. Mols. Graduate School Prod. Ecology & Resource Conservation. Funded by WU.

Objectives. In apple orchards aphids play an important role. The most important species are the rose-apple aphid (*Dysaphis plantaginea*), the woolly apple aphid (*Eriosoma lanigerum*), the green apple aphid (*Aphis pomi*), the apple grass aphid (*Rhopalosiphum insertum*) and the rosy leaf curling aphid (*Dysaphis devecta*). Their numbers fluctuate strongly from year to year depending on biotic (natural enemies, host plant) and abiotic factors (temperature, rainfall etc). In the Netherlands non of these factors can separately keep the aphid densities constantly under an acceptable level for the fruit growers. Therefore, they are often controlled by means of spraying. To prevent unnecessary spraying more knowledge has to be obtained about the role of weather and natural enemies on the development of aphid populations. As a case study research has been carried on the woolly apple aphid predators-parasite complex to gain more insight in its functioning in the field.

G050.913. Natural control of insect pests in orchards: incidence, impact and manageability of some parasitic wasps. 1991-2000. J.P. Zijp, L. Blommers & J.C. van Lenteren. Graduate School Production Ecology. Funded by Ministry of Agriculture.

Objectives. Integrated pest management (IPM) in Dutch orchards is based on the natural control of phytophageous mites by a predatory mite. Selective insecticides are applied against most other pests. For control of some occasional pests, i.e. apple blossom weevil, apple sawfly and apple leaf midge, only broad spectrum insecticides are available, which may reduce the impact of natural enemies. The aim of this project is to explore the possibility of promoting parasitic wasps to control these pests. The relation between population densities of pest and antagonist will be studied during several years. Also, we shall try to elucidate the most important mortality factors.

Progress in 2000. Experimental work has been finished, project is in thesis writing stage.

PE-new. 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. Graduate School Production Ecology & Resource Conservation.

Objectives. Two closely related parasitic wasps, *Cotesia glomerata*, a generalist species, and *C. rubecula*, a specialist species, differ profoundly in their ability of associative olfactory learning. We study this phenomenon in its evolutionary context, by integration of behavioral ecology and neurobiology. Central in our approach lies the notion that differences in behavioral plasticity between specialist and generalist species are triggered by neural constraints on the amount of information that can be processed simultaneously by the insect's brain. Using the comparative approach, we will investigate
(1) differences in morphology of olfactory sensilla on the antennae of both wasp species, (2) differences in electroantennogram and single cell responses before and after olfactory memory training, (3) differences in the interneurons that mediate the reinforcing stimulus in associative olfactory learning, (4) differences in nitric oxide synthase activity (involved in long-term memory formation) in the olfactory pathway of the two wasp species.

Progress in 2000. The olfactory sensilla on the antennae of *C. glomerata* and *C. rubecula* were studied by scanning electron microscopy. Both male and female antenna were examined, with special emphasis on the elongated sensilla placodea (pore plate sensilla). Only quantitative differences were found between the two species or between the sexes, there were no qualitative differences. The antennae of female wasps had fewer pore plate sensilla than of male wasps, and antennae of the generalist *C. glomerata* had fewer poreplate sensilla than of the specialist *C. rubecula*.

PE32-94h(G050.911). Biological control of thrips pests: Evaluation of hymenopterous parasitoids as potential biological control agents of Western Flower Thrips (*Frankliniella occidentalis*). 1991-2000. A.J.M. Loomans, J.C. van Lenteren. Graduate School Production Ecology. Funded by EU.

Objectives. The Western Flower Thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), presently is the number one key pest in many glasshouse crops in Europe, vegetables as well as ornamentals. Research on biological control agents has not yet resulted in a satisfactory solution or is still in an experimental phase. In collaboration with the University of Bologna (Italy) and IRTA-Cabrils (Spain), an EU-CAMAR project on "Biological control of thrips pests" has started in 1991, in order to collect, evaluate, mass produce and commercially apply natural enemies of thrips species. The objective of our laboratory within this project is, to collect and evaluate hymenopterous parasites for the biological control of thrips pests in general and *F. occidentalis* in particular. Based on biological and behavioural criteria, parasites will be evaluated in laboratory experiments and small experimental glasshouse tests. Using the results of this evaluation, candidates will be selected to develop a biological control method.

Progress in 2000. This project is in the writing phase.

PE33-97g(G050.932). Entomopathogenic fungi for the control of whiteflies in greenhouses, with special reference to the genus *Aschersonia*. 1994-1999. E.T.M. Meekes, J.J. Fransen & J.C. van Lenteren. Graduate School Production Ecology. Funded by Ministry of Agriculture.

Objectives. Biological control of insect pests of ornamental crops is particularly difficult as a result of the low damage thresholds. Entomopathogenic fungi can be a valuable addition to the existing biological control methods. In this research project special attention is given to the genus *Aschersonia*, fungi specific to whitefly. Different isolates are evaluated for control of *Bemisia argentifolii* and *Trialeurodes vaporariorum*. The research will concentrate on relationships between host, host plant, microclimate and fungal performance under greenhouse conditions.

Progress in 2000. Experimental work has been finished and project is in thesis writing phase. The thesis will be defended in June 2001.

PE33-97j. Biology of *Amitus fuscipennis*, natural enemy of whiteflies. 1996-2001. M. Manzano & J.C. van Lenteren. Graduate School Production Ecology. Funded by WOTRO.

Objectives. *Amytis fuscipennis* is a naturally occurring parasitoid of greenhouse whitefly in Columbia. Greenhouse whitefly regularly reaches pest status on beans in Columbia. Aim of this project is to study the biology of this natural enemy and pest under field and laboratory conditions and to determine under which conditions the parasitoid can be used in the field. Habitat management might be an option for augmentation of the control effect of this parasitoid.

Progress in 2000: The distribution of the parasitoid *Amitus fuscipennis* MacGown & Nebeker, was determined by field surveys of different crops infested with the whitefly *Trialeurodes vaporariorum* in Valle del Cauca, Colombia. The parasitoid occurred
from middle (400-1000 m) to high altitudes (above 1000 m) and it was the only whitefly parasitoid species observed at altitudes over 1460 m. At lower altitudes, *Encarsia* spp occurred together with *A. fuscipennis*. To determine seasonal abundance of the whiteflies *T. vaporariorum* and *Bemisia tabaci* Gennadius, and their parasitoids, we performed field experiments in sprayed and unsprayed fields during a cropping season of snap bean in Pradera, Valle del Cauca, Colombia. Substantially larger populations of whitefly nymphs occurred in the unsprayed field than in the sprayed field in this area. The parasitoid *Encarsia nigricephala* Dozier was more prevalent than *A. fuscipennis*. Parasitoids were more frequent in unsprayed than in sprayed fields and parasitoid populations in the sprayed field were larger than those of whiteflies at the end of the cropping season. Work in this project was concluded and the PhD thesis was defended in November 2000.

PE-new. Evaluation of *Encarsia formosa* and *Amitus fuscipennis* for control of whiteflies in greenhouses in Colombia. 1996-2000. R. de Vis &, J.C. van Lenteren. Funded by Belgian Government.

Objectives. The 3-year project is being carried out at the Horticultural Research Centre (HRC) of the University of Bogota Jorge Tadeo Lozano. The aim is the development of biological control of *Trialeurodes vaporariorum* using *Encarsia formosa* and *Amitus fuscipennis* on greenhouse tomato in Colombia. The project
includes basic studies on the biology of the greenhouse whitefly, life history of *A. fuscipennis*, searching behaviour of *A. fuscipennis*, and the interaction of *A. fuscipennis* and *E. formosa*. Additionally, the biological control efficiency of both parasitoids is being evaluated under local greenhouse conditions to adapt the biological control system and implement the technology on commercial farms.

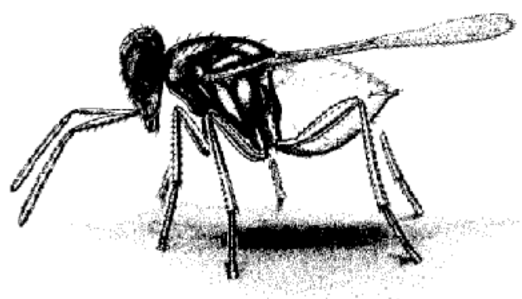
Progress in 2000. The time allocation and the host handling behaviour of *A. fuscipennis* on clean and infested tomato leaflets were quantified. *A. fuscipennis* discriminates whitefly larvae parasitized by itself but does not discriminate larvae parasitized by a conspecific. In interaction experiments between *E. formosa* and *A. fuscipennis* it was found that both parasitoids do not discriminate whitefly larvae parasitized by a heterospecific. From whitefly larvae parasitized by both parasitoids short after each other, the parasitoid that parasitized first emerged mostly. In a greenhouse trial at the HRC, control of *T. vaporariorum* by *A. fuscipennis* on tomato was partially successful after introducing 60 *A. fuscipennis* pupae during the first nine weeks. After three months the whitefly population increased from less than 3 adults per plant to more than 30. In a subsequent trial, successful control was obtained introducing

30 pupae of both *E. formosa* and *A. fuscipennis*. *E. formosa* was the predominant parasitoid and the whitefly density never went over 1.2 adults per plant.

PE-new. Evaluating Environmental Risks of Biological Control Introductions into Europe (ERBIC). 1998-2002. A.J.M. Loomans & J.C. van Lenteren. Graduate School Production Ecology & Resource Conservation. Funded by EU-FAIR.

Objectives. Biological control of insect pests has become a key component of sustainable agriculture in Europe over the past decades. In this project we aim 1) to determine benefits and riks of different types of biological control for agriculture and the environment, 2) to develop reliable methods for assessing the potential risk of import and release of exotic biocontrol agents and 3) to design EU-guidelines to ensure that introduced biocontrol agents are environmentally safe. Assessments will be made for various categories of natural enemies, agricultural settings and ecosystems. Our case-study will focus on direct and indirect effects of a specific category of natural enemies: exotic, host specific whitefly parasitoids (*Encarsia formosa, E. pergandiella*) released in greenhouse systems for whitefly control, in temperate and Mediterranean zones. Aspects include: competition between parasitoids, (primary- hyperparasitic, exotic - endemic), displacement effects, the effects on endemic and exotic host species, outdoor survival and dispersal, and the potential risk for the ecosystems they invade.

Progress in 2000. Surveys of the exotic whitefly and parasitoid fauna near commercial greenhouses, in natural habitats and private gardens in The Netherlands resulted in the collection of qualitative and quantitative data on four native species: *Encarsia tricolor E. aleurochitonis, Encarsia* sp. and *Euderomphale chelidonii* parasitizing native whitefly species. *Encarsia formosa,* an exotic species which is mass-released seasonally, was collected outdoors on greenhouse whitefly, *Trialeurodes vaporariorum,* as well as on native whitefly species (*Aleyrodes proletella* and *A. lonicerae* on blackberry, strawberry and *Lonicera*). Monitoring whitefly and parasitoid populations inside greenhouses and outdoors showed that few *E. formosa* adults leave
the greenhouse, and few are found outdoors parasitizing native hosts. Experiments carried out in cabbage plots outdoors in September, naturally infested with *Aleyrodes proletella* (cabbage whitefly), showed that adult *E. formosa* survived for a more than a week, but with a low capacity to disperse from their point of release and low parasitisation rates. Overwintering experiments indicate that *E. formosa* is able to survive to next spring in unheated, though still protected environments, but not in the open field.



PE-new. Enhancing the biocontrol of the Western Flower Thrips (*Frankliniella occidentalis*) with the predatory bug (*Orius laevigatus*) on greenhouse cucumber. 1998-2001. J. Hulshof, A.J.M. Loomans, J.C. van Lenteren. EU-Funded

Objectives. To develop a strategy of using additional food sources for the predatory bug *Orius laevigatus*. The additional food should allow the predator to build up a population and persist in the crop, greenhouse cucumber, in the absence of its prey the Western Flower Thrips. The project aims at understanding the interaction between pest, predator and an alternative food source.

Progress in 2000. In a greenhouse experiment the effect of the presence of alternative food sources (pine pollen, *Ephestia kuehniella* eggs) on the interaction between *F. occidentalis* and its predator *Orius laevigatus* on cucumber was studied. The *Orius* bugs were eventually able to control the thrips, but adding the alternative food neither enhanced the establishment nor supported the persistence of the bugs after the thrips disappeared. The food sources might simply not support the bugs' persistence, or the positive effect was not found due to the canibalistic behavior of the bugs. This well known behavior might have occurred specially at the end of the experiment when the bugs and the thrips concentrated around the alternative food sources.

PE 33-98a. Foraging strategies in Entomopathogenic Nematodes. 1998-2001. M.I.C. Boff, J.C. van Lenteren, P.H. Smits (DLO). Graduate School Production Ecology & Resource Conservation. Funded by Brazilian Government.

Objectives. To investigate the foraging strategy of the entomopathogenic nematode *Heterorhabditis megidis* in order to elucidate (a) how nematodes distribute from a natural host or artificial application, (b) what the influence of host quality is on the production of nematodes and their distribution, (c) how can inter- and intra-specific interactions in dispersion and infection behaviour be described, (d) how polypagous the species is, (e) which factors effect the dispersion of this species in the soil, and (g) what the potential is of this species for seasonal inoculative releases in greenhouses or the open field.

Progress in 2000: Work in this year mainly concentrated on the searching behaviour of the nematodes. Experiments were done in petridish arena's and olfactometers. Results showed that the nematodes react best to a combination of damaged host plant roots and insect hosts. This work provided important new insight in the searching behaviour of commercially interesting nematode natural enemies.

PE&RC 31 00t - Introduction of the gene(s) for zoophily from *Anopheles quadriannulatus* into anthropophilic *An. gambiae sensu stricto* by backcrossing. 1998-2000. H.V. Pates and W. Takken. Graduate School Production Ecology & Resource Conservation. Funded by WHO-TDR. In co-operation with London School of Hygiene and Tropical Medicine.

Objectives Within the *Anopheles gambiae* complex strong differences in host preferences are present, which are believed to be olfactory mediated*. An.*

quadriannulatus is zoophilic, and not considered a malaria vector. In the wild cross-mating between siblings is found in less than 0.1% of the population, and hybrid males are sterile. Hybrid females, however, are fertile. In this study we intend to bring the gene(s) that code for zoophily from *An. Quad.* into *An. Gam.* by backcrossing. In this way we hope to retain most characteristics

of *An. Gam.*, while altering her host preference from being anthropophilic to zoophilic.

Progress in 2000. Human and cow skin washings were evaluated in the wind tunnel to develop a bioassay to separate mosquitoes showing *gambiae* –like characteristics or *quadriannulatus* –like characteristics. Hybrid *gambiae* x *quadriannulatus* mosquitoes
were bred and their response to skin washings was tested in the wind tunnel. The effect of *An. quadriannulatus* genes was more marked in the first *quadriannulatus* backcross (hybrid female mated with a *quadriannulatus* male). However, the first *gambiae* backcross showed a similar behaviour to that of the pure strain of *An. gambiae*, indicating that the genes for anthropophily may be dominant in character. A field study to investigate the host seeking behaviour of *An. quadriannulatus* in Ethiopia was designed and carried out. Specimens were collected from light traps and resting catches and then analysed for sporozoites using the ELISA technique; bloodmeals were analysed using the precipitin technique. All *An. Gam. s.l.* specimens will be identified to sibling species level using PCR.

PE&RC 32 01b - Integrating Geographical Information Systems and Cellular Automata for the Assessment of Malaria Risk and Control. 1998-2002. P. Schneider and W. Takken. Funded by WOTRO. In co-operation with Maastricht University. Graduate School Production Ecology & Resource Conservation.

Objectives The study will assess malaria risk factors as determined by environmental characteristics and the effects of these factors on mosquito population dynamics, biting frequency and behaviour. This will be done as a comparison study between distinctly different geographical regions of the world where malaria is endemic. These are Sulawesi, Indonesia, western Kenya and Rondonia, Brazil. The uptake and transmission of malaria parasites by mosquito vectors will be assessed in relation to vector and environmental characteristics. It is expected that the results of the study will reveal the most significant factors that determine malaria mosquito density and disease transmission in relation to global change. The data will be used to validate simulation models on malaria risk. These models use cellular automata techniques, to allow separate inputs of essential variables.

Progress in 2000. At the field site in Western Kenya data were collected on malaria prevalence and mosquito (biting) density in two selected villages. The villages are markedly different in transmission characteristics. In Miwani village malaria prevalence in schoolchildren was high (60-80%), while in Fort Ternan village the prevalence in

schoolchildren varied between 6 and 16%. Because the rainy seasons in 2000 were highly unusual, it was mostly dry, mosquito densities were erratic and highly variable. In Miwani mosquitoes were present at all times, peaking in July, corresponding with the height of the rains. During >144 house visits in Fort Ternan, spread over the year, only 3 adult anopheline mosquitoes were found, suggesting that malaria transmission in this village might occur elsewhere. Anopheline mosquito larvae were found around water taps and in hoofprints along a river, and a proportion of these turned out to be the efficient vector *An. gambiae sensu stricto*. It is therefore planned to conduct further studies to verify the timing and site of mosquito biting. Field studies
in Brazil were unfortunately upheld because of new laws governing the participation of foreign scientists in collection of biological and medical data.

PE-new. 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. Graduate School Production Ecology & Resource Conservation. In cooperation with Maastricht University.

Objectives: An increased incidence of vector-borne diseases is to be expected as a result of climate change. The latter will have a profound effect on the ecology of disease vectors, resulting in changes in population dynamics and distribution. This study will assess the impact of the environment on the aquatic stages of malaria and dengue vectors, with emphasis on malaria vectors in Kenya. Field studies will be conducted in 3 different sites to investigate the effect of biotic and abiotic variables on mosquito development and survival. It will be attempted to establish a correlation between larval and adult densities. Data will be used to validate simul. models for the prediction of malaria risk in relation to climate change.

Progress in 2000. We continued studying the (aquatic) larval stages of *An gambiae* s.l., the main vector of malaria in Africa. Special attention was given to the dynamics of the larval populations in relation to environmental factors. We found that there was a significant correlation between rainfall and the number of breeding sites one week later. This probably reflects the time lag between the creation of sites by rain and the actual colonisation of the sites by malaria mosquitoes. Besides, we found a significant increase of *An. gambiae* s.s. from the start of the rainy season, to the detriment of the other sibling species *An. arabiensis*. We conclude that these dynamics on a small scale will have their effects in determining the risk of malaria, since both sibling species differ greatly in their feeding and resting biology.

PE&RC 32 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. Funded by WU, CDC (Atlanta) and WHO-TDR. In co-operation with KEMRI, Kenya, ICIPE, Nairobi, Kenya and Centers for Disease Control, Atlanta. Graduate School Production Ecology & Resource Conservation.

Objectives The distribution of bites by female *Anopheles* on humans is an important element in models of malaria transmission. Until today technical obstacles prevent precise identity of humans upon which a mosquito has fed. We will use a DNA profiling technique to determine the natural feeding patterns of mosquitoes (upon humans) in Asembo bay, western Kenya. First, we will determine the effect of age, size and sex upon attractiveness of humans to 3 vectors of malaria in the study area. Then the effect of host-parasite relationships upon attraction will be investigated, to establish whether malaria parasites mediate host-seeking behaviour of their mosquito vectors. Lastly, odour profiles of the 3 indiv. will be compared to determine variability in attractiveness is linked to olfactory cues.

Progress in 2000. Studies were conducted in semi-field situations in a greenhouse at Mbita Research and Training Station, on the shores of Lake

Victoria, Kenya. A large 3-armed olfactometer was constructed, which is able to host human individuals in each arm. *Anopheles gambiae sensu stricto* were released from the centre of the olfactometer, and it was assessed to what extent mosquitoes respond to complete and incomplete volatiles of human hosts.

Significant differences in attractiveness for *Anopheles gambiae* was found between individuals. Studies then focused on the effect of natural body heat and moisture on the response of mosquitoes. There was interaction between body heat and volatiles, as expected. Studies on the effect of malaria parasites on human attractiveness to Anopheles gambiae were begun, by comparing the attractiveness of non-infected and *Plasmodium* infected human hosts. All humans used in the study are volunteers, having acquired the malaria infection naturally. Malaria parasite carriers are being treated with appropriate drugs before being discharged from the experiment.

PE32-96c/PE33-97i. Biological control of bruchids in stored cowpea in West-Africa. 1997-2001. C. Stolk & A. van Huis. Graduate School Production Ecology. Funded by WU.

Objectives. A conservation strategy of biological control, implying that natural enemies are preserved in the system, seems appropriate for the stored cowpea - bruchid system. We concentrate on egg parasitoids of the genus *Uscana* (Hym.: Trichogrammatidae). A computer model that simulates the population dynamics of both bruchid and parasitoid will be used to assess which aspects of the system are sensitive to manipulation. Several aspects of the biology of both bruchids and parasitoids that are relevant in constructing the model, will receive attention in laboratory experiments and in mathematical models. **Progress in 2000.** The spatial oviposition data of *Callosobruchus maculatus* were further analysed to show what the consequences are of *Callosobruchus* egg distr. for *Uscana lariophaga*.. A paper on this subject has been submitted for publ. in an international scientific journal. The foraging behaviour of *Uscana lariophaga* was studied in great detail in an experimental arena with one layer of cowpea seeds.

Both location and behaviour of the parasitoid were recorded simultaneously.These data will be used in the construction of a model which describes the foraging behaviour of *Uscana lariophaga*. We continued with experiments in which we measured the dispersal ability of *Uscana* in stored cowpea. We did so in both large and small experimental storage containers. In the large containers, we investigated the effect that the distance between the release point of *Uscana* and the host patch has on the probability that the host patch was found, and on the number of parasitized eggs. In the small containers we investigated the effect of distance, foraging time interval, and orientation (upward, downward, and horizontal). Both foraging time and distance appeared to have a significant effect on host finding probability and on the number of parasitized eggs, but the effect of time was more important than the effect of distance. *Uscana* also showed a neg. geotaxic response.

EPS2d-17 . 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. Grad.

School Exp. Plant Sc. Funded by DGIS.

Objectives. The main objective of this project is to develop phytochemical-based methods to protect the cowpea (*Vigna unguiculata* L. Walp) from damage inflicted by the bruchid beetle *Callosobruchus maculatus* (Fab.) (Coleoptera: Bruchidae) as a necessary alternative for the currently used synthetic pesticides. *C. maculatus* (Fab.) is the main post-harvest factor constraining longer term storage of cowpeas in sub-Saharan African subsistence agriculture.

A second objective is to assess the durability of such strategies by paying explicit attention to the effects on beneficial insects, to resistance development and to genetically determined variability at the side of the target insects. This project is carried out in the framework of a bilateral research program between the Republic of Benin (Groupe Interinstitutionnel Protection des Végétaux au Bénin) and The Netherlands entitled 'Lutte Integrée Contre Les Principaux Organismes Nuisibles Du Niébé Au Bénin'.

Progress in 2000. A review article on the use of plants as insecticides or as insect repellent agents in seed storage structures has been completed and awaits publication. It appeared that the bean weevil *Callosobruchus maculatus*, collected in Niger and reared in the laboratory since 1992, has not changed its reproduction cycle when compared with recently collected beetles from Southern and Northern Benin (reared since November 98 and February 99). However, differences were found for the performance of the beetles on different varieties of beans. The Californian blackeyed cowpea, currently used in the laboratory, was more suitable for the rearing and testing of plant effects on *Callosobruchus maculatus* than the variety podjiguegue from Benin. Thirty plants that are used traditionally in Benin to prevent damage by *Callosobruchus mac.* have been tested for their toxicity and repellent effect on the beetles. Ten of these plants had toxic effects, seven were repellent and five reduced oviposition. Of the most promising plants, aqueous extracts were made. Thus, six volatile oils and four slurry-like extracts were obtained. The compounds in the volatile oils were elucidated and the oils were tested for repellence against the beetle. Oils were more potent than the crude plant material they were made of.

PE33-99a. The role of indigenous predators on maize stem borers in coastal Kenya. 1995-2000. M.J. Bonhof, A. van Huis & W.A. Overholt. Graduate School Production Ecology. Funded by DGIS. Collaborative project between International Centre of Insect Physiology and Ecology (ICIPE), Kenya, and Wageningen University.

Objectives. Lepidopteran stem borers are a major constraint to maize production in Africa. The exotic *Chilo partellus* (Lepidoptera: Pyralidae) is the predominant stem borer species in East and southern Africa. In 1991, a project concentrating on the biological control of *C. partellus* started in Kenya. Within the context of the project, a study was carried out to analyse the role of local predators on stem borer populations. From 1995 to 1998, surveys were carried out at several farmers' maize fields along the Kenyan coast to obtain information on predator species and abundance. In general, predator numbers were low. Ants were the most abundant potential predators, while spiders, earwigs and cockroaches were occasionally found. Laboratory studies and field observations identified ants as predators of *C. partellus* eggs, but other groups seldom preyed on eggs and young larvae. In the field, predators had an impact on the disappearance of eggs and, in some trials, of pupae, but disappearance of larvae was not caused by predators.

Progress in 2000. Project has been completed. A PhD thesis has been defended.

PE35-99a. Genetic variability in *Cotesia flavipes* Cameron and its significance for population establishment in the biological control of lepidopteran stemborers, 1998-2002 E.I. Niyibigira, R. Stouthamer & W.A. Overholt. Graduate School of Production Ecology. Funded by WOTRO.

Objectives. The value of genetic diversity of the released natural enemies for the effectiveness of biological control is a topic that is much theorized about but little experimental work has been done to test its importance. The purpose of the proposed research is to a) develop methods to maintain genetic variability in mass cultures, b) determine the relationship between genetic variability of the released population and the probability of establishment in the field, c) improve the biological control efficiency of established but possibly genetically impoverished populations of the natural enemy and 4) to determine the level of genetic variability found in natural populations of the parasitic wasps. Releases of *Cotesia flavipes*, a parasitoid of stemboring lepidoptera, with various levels of genetic variability will be done on Zanzibar and their spread and establishment will be followed over time.

Progress in 2000. Wasps were established on Zanzibar. Experiments were done to determine various life history characters of the different lines. In addition we tested many microsatellites of *Cotesia glomerata* on *C. flavipes* however none of these showed variation. Therefore we used the PIMA technique to find new microsats, this is till in progress. In addition sex ratio data of *Cotesia sesamiae* and *C. flavipes* were analysed to determine if evidence could be found for the occurrence of diploid males.

PE39-97a. Designing improved Desert Locust survey operations and control strategies using scenario studies. 1998-2002. W.T. Gebremedhin & A. van Huis. Graduate School Production Ecology. Funded by Dutch Government (DGIS-FAO).

Objectives. This project is executed in the framework of the DGIS funded FAO project "Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases: improvement of Desert Locust survey operations and control strategies" in the Central Region (the countries bordering the Red Sea). Wageningen University collaborates with the FAO in carrying out scenario studies for improved Desert Locust survey operations and control strategies. The collaboration consists in developing simulation models for locust survey and control operations.

Progress in 2000. The desert locust (*Schistocerca gregaria* Forsk.) 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. To determine the spatial pattern of desert locust and its relationship to habitat factors, a systematic survey was carried out in a 20 by 120 km area in the coastal plains of Eastern Sudan, near the Red Sea. Locust samples were taken in a 5 km grid on 9 occasions between 7 December 1999 and 11 February 2000.

Locusts were mostly found in crop lands, with millet and patches of the weed *Heliotropium supinum* grown on a fine sandy soil type. Much lower densities were observed in grazing lands and on clay soils with a high salt content. Our results suggest that vegetation and soil data may be used as indicators of areas where locusts are most likely to be found. If survey is focused on those areas, the chance of locust detection will be increased, and the time and cost of survey reduced.

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. Graduate School Production Ecology & Resource Conservation. Funded by PRODETAB, Brazil.

Objectives. An important aspect for the success of mass-release programs is the right choice of the strain to be used for mass-rearing. Strains of the parasitoid *Trichogramma* may be improved by artificial selection to predict the success of *Trichogramma* before releases are made. The purpose of this project is to identify and select important characteristics in *Trichogramma* strains to be used in biological control programs.

Progress in 2000. *Trichogramma* identification has been traditionally difficulty despite of the advances in morphological studies and in some cases males genitalia are not able to separate species. *Trichogramma* DNA sequencing based on the internally transcribed spacer (ITS2) has proved to be a useful tool to distinguish between species. Five species obtained from Peru (*T. pretiosum*, *T. exiguum, T. lopesandesnesis*, *T. nerudai* and *T. bactrae* (Trichogrammatoidea) have been studied. PCR has been performed to amplify *Wolbachia* DNA in four *Trichogramma* species (*T. pretiosum, T. atopovirilia, T. cordubensis* and *T. brevicapilum*). In this study we report the first discovery of infected *T. pretiosum* collected in Brazil. In addition, temperature effect study on *Wolbachia* transmission on this thelytokous species showed that the higher the temperature the lower the longevity. No difference on the parasitism rate was found between 25 and 30°C. On the other hand, at 30°C the sex ratio strongly decreased on the 4th day (0.57) and reached 0.0 on the 9th day. Horizontal transmission study of *Wolbachia* between different lines and species of *Trichogramma* (*T. pretiosum*, *T. galloi*, *T. atopovirilia* and *T. acacioi*) was performed. No case of horizntal transfer was obtained. Crossing experiments between nine *T. pretiosum* lines showed few cases of the one-way partially incompatibility. Sex ratio in crosses within strains tended to be more female-biased than in crosses between strains.

PE-new. Evaluating farmers' knowledge, perceptions and practices: a case study of pest management by fruit farmers in the Mekong Delta, Vietnam. 1999-2000. P. van Mele, N.T.T. Cuc, A. van Huis and J.C. van Lenteren.

Objectives. Since the Doi moi in 1986, Vietnam's government policies have increasingly emphasized diversification of agricultural production into high value crops. Over the period 1985-1995, fruit production in the Mekong Delta increased from 92,100 to 175,700 ha. The potential of the fruit industry is, however, not yet fully exploited due to pest problems as well as marketing, credit and transport problems. Pesticides and chemical fertilizers have become increasingly important at the expense of traditional practices of biological control.

EPS2d-024 new. Chemical ecology and management of the banana weevil *Cosmopolites sordidus*. W. Tinzaara, C. Gold, A. van Huis and M. Dicke. 2000-2005. Graduate School Experimental Plant Sciences. Funded by IITA-Uganda and Rockefeller Foundation.

Objectives. *Cosmopolites sordidus* is one of the most serious pests of bananas. The insect causes tremendous yield losses and shortens plantation life spans if not controlled.

Because this pest remains mainly concealed and its larvae feed by mining the banana rhizome and pseudostem, control either by conventional insecticides or even classical biological control method is difficult The overall objective is to develop an infochemical based trapping system for the banana weevil that is cost effective and appropriate for Uganda conditions. The research focus therefore is to elucidate pheromone and kairomone trap efficiency as related to weevil behaviour and environmental conditions. The study will also investigate the impact of adult removal on weevil population dynamics and damage. An effort will be made to evaluate the potential of combining infochemical use with biological control methods (predators and entomopathogens) for the management of the banana weevil.

Progress in 2000. A literature review has been written.

EPS2d-021. 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. Graduate School Experimental Plant Sciences. Funded by IFS, Sweden.

Objectives. Plants have two defense options: (1) direct defense against the herbivores, using physical or chemical factors, or (2) indirect defense by bypassing the herbivores and influencing the natural enemies directly. Many farmers in developing countries do not have the resources to buy and apply pesticides. Biological control in the form of local natural enemies and botanical pesticides that can be easily prepared from locally abundant trees are free to the farmer, while host plant resistance costs no more than the planting material for the crop itself. Therefore these methods are uniquely suited to low-input integrated pest management systems, provided the methods do not interfere with one another. This study will investigate whether host plant resistance, biological control and chemical control using botanical pesticides are compatible in integrated pest management systems for the diamondback moth in South Africa.

A promising source of plant resistance to *P. xylostella* is found in leaf wax characteristics of Brassicacea, particularly in glossy lines. Cabbage is a common crop among small-scale farmers as it requires little input, and produces fairly high yields. The importance of this crop in the small-scale rural farming community led to the testing of three different cabbage varieties with differing levels of resistance. Indian mustard also shows some potential for use as a trap crop and therefore is also included as a test plant.

Progress in 2000. A literature review has been written and first experiments on the effects of botanical pesticides on *Plutella* have been initiated.

4A. - VI. SENSORY PHYSIOLOGY IN INSECT-PLANT INTERACTIONS.

EPS 2d-5. Sensory, behavioural and nutritional effects of plant substances on host plant and host insect evaluation and utilization by insects 1996-2001. J.J.A.van Loon, H.M. Smid. Graduate School Experimental Plant Sciences. Funded by WAU.

Objectives. Oviposition and feeding behaviour of plant feeding and parasitic insects are to a large extent influenced by constitutive and induced plant chemicals. Recognition, acceptance or rejection of host plants or hosts are based on chemosensory information. This project focusses on the physiological effects of phytochemicals in several insect-plant-natural enemy combinations. Central questions are: which phytochemicals affect insect feeding and oviposition behaviour? Which receptors mediate the behaviour? Specificity and sensitivity of chemoreceptors are studied electrophysiologically. To what extent and how do secondary plant chemicals affect insect performance (growth and developmental rates, pupal weights, food utilisation)? This involves mechanistic studies of host plant resistance. Bioassays and direct observations are employed to quantify behavioural responses. The main system consists of cruciferous plants, oligophagous *Pieris* butterflies and *Cotesia* parasitoids of *Pieris* larvae. Bioassay-guided chemical isolation and identification of biologically active compounds are performed in close collaboration with the Department of Organic Chemistry.

Progress in 2000. Feeding of *Pieris brassicae* or *P. rapae* caterpillars on Brussels sprouts plants induces the emission of synomones that attract natural enemies of the caterpillars, *Cotesia glomerata*, a generalist parasitoid of Pierid caterpillars, and *C. rubecula*, a specialist on *P. rapae*. Previous research on this tritrophic system has identified 80+ volatiles in the headspace of herbivore-damaged Brussels sprouts plants. We addressed the question which of these volatiles are perceived by the two parasitoid species. Headspace odours from both *P. brassicae*- and *P. rapae*-damaged Brussels sprouts plants were analyzed by coupled gas chromatography- electro- antennography (GC-EAG). Twenty volatiles evoked consistent EAG reactions in the antennae of both species and the corresponding peaks were subjected to GC-MS analyses. Eighteen volatiles could be identified with GC-MS. Fourteen of these were obtained in pure form and subjected to GC analysis and off-line EAG studies. Among the volatiles that evoked a GC-EAG response were compounds that were previously found to be induced by caterpillar feeding, but also substances which are not induced. The numbers of volatiles eliciting EAG responses in *C. glomerata* and *C. rubecula* were identical, except for one unidentified substance which evoked an EAG response in the antenna of *C. rubecula* only.

EPS2b-28. Insect-plant interactions during stylet penetration by aphids. 1994-2003. W.F. Tjallingii and T. Hogen Esch. Graduate School Experimental Plant Sciences. Funded by WU.

Objectives. In the projects on aphid-plant interactions we want to investigate and develop experimental procedures to elucidate: (i) where and when, what substances are (a) secreted by aphids into plants, and, (b) taken up by aphids from the plants, and how these substances may contribute to acceptance or rejection of the plant as part of the resistance mechanism. (ii) How the structure is of food plant selection behaviour in case of

acceptance and rejection.

Whether there are general patterns or sequences of events that are modified by each aphid-plant combination. (iii) How cells are treated during stylet penetration in plant tissues and what the time schedule is of the effects. (iv) What is enabling aphids to exploit plants as a source for continuous sap feeding without being obstructed by plant defense mechanisms. (v) Principles that can be used in endurable resistance against aphids as direct crop plant pests as well as vectors of crop plant diseases. When aphid stylets penetrate (probe) plants, signal waveforms can be recorded by attaching one electrode (gluing a thin gold wire) to the aphid's dorsum and one electrode to the plant (inserted in the soil). This electr penetration graph (EPG) is one of the major experimental techn. used in this project.

Progress 2000. The general focus is on the role of salivary secretions by aphids in induced plant reactions. Potentially, altered plant properties (constitutive or induced) with respect to plant responses can provide a source of host plant resistance to insects and the success of pathogen transmission by insects as vectors. Acquisition and inoculation of semi-persistently transmitted viruses during stylet penetration of plants showed that no unknown periods of salivary excretion or other ejection are involved. So far 4 secretion periods have been identified, acting on different tissue levels in the plant. Salivary proteins are poorly known in aphids due difficulties in their isolation and identification (pilot study; see annual report 1998).

EPS2b-75. 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. Graduate School Experimental Plant Sciences. Funded by STW.

Objectives. This is a joint project with the laboratory of virology (2 Ph.D. students). The Entomological part of this project aims to identify the behavioural (probing) activities responsible for the acquisition and inoculation TSWV by using close video in combination with EPGs. Once these activities are identified their possible modification will be studied as caused host plant resistance to the vector and to the virus, as well as caused by virus infection of the plant. Migration and population developmental aspects will be studied later.

Progress in 2000. With the combined EPG and close range video techniques the feeding behaviour of the western flower thrips has been subdivided into four different EPG waveforms. Experiments were started to correlate these waveforms with specific feeding/probing activities. Using radioactive labeled diet in combination with EPG recording the ingestion by thrips could be correlated with one specific waveform (R). Also, the specific feeding rates of the different life stages were measured. Attempts to identify a specific saliva excretion waveform were not successful so far.

4 B. SEMINARS

R.P. de Almeida

- *Wolbachia*-induced parthenogenesis in a Brazilian *Trichogramma pretiosum* population.
  Ede, December 15th, 2000

J. Burger

- How to behave: evolutionary ecology of the whitefly parasitoid *Encarsia formosa*, Wageningen, the Netherlands, 28 March, 2000.
- Maximising lifetime reproductive success: a dynamic state-variable model, Wageningen, the Netherlands, 28 August 2000.
- How to behave: host-feeding strategies in the whitefly parasitoid *Encarsia formosa*, Haarlem, the Netherlands, 1-6 October, 2000.

M. Dicke

- Control of insect pests: host plant resistance and biological control. Cogem, Wageningen, 31 January 2000 (invited).
- Multitrophic effects of SOS-signals from plants that are attacked by herbivores. Institute of Plant Diseases and Plant Protection, University Hannover, Germany, 29 February 2000 (invited).
- Informatie: communicatie, spionage, en contraspionage.. Wageningen, 24 March 2000 (invited).
- Durable crop protection in a multitrophic setting. Plant Research International, Wageningen. May 2, 2000 (invited).
- Infochemicals in multitrophic interactions. Wageningen University, 21 June 2000.
- Plants 'cry for help' – Do plant breeders and biocontrol companies listen? 21 August 2000, Iguassu, Brazil. (invited)
- Do plants benefit from the emission of parasitoid-attracting volatiles? Haarlem, The Netherlands, 1-6 October 2000. (with J.J.A. van Loon, J.G. de Boer, R.M.P. van Poecke)
- Biological control and GMO. PE Symposium. 12 October 2000. H.J. Bouwmeester, F.W.A. Verstappen & M. Dicke (invited).
- Plant and crop sciences: multifaceted and exciting. Wageningen 13 and 14 October 2000 (invited)
- Plants, herbivores and their natural enemies: communication, exploitation, espionage and counterespionage.. Wageningen. 16-18 October 2000 (invited).
- Indirect interactions mediated through chemical information: costs and benefits. Netherlands Institute of Ecology, Heteren, The Netherlands, 24 October 2000 (invited)
- Does it pay plants to 'cry for help'? BWV Biologica, Wageningen, 15 November 2000 (invited)
- Formation of predator attracting volatiles in plants. 8 December 2000, Naaldwijk. (H.J. Bouwmeester, F. Verstappen, P. Ramakers & M. Dicke)

- Inducible defences of plants against insects: from mechanism to function. Ede, 15 December 2000 (invited)
- Chemical ecology of insect-plant interactions. Utrecht, 18 December 2000. (invited)

M.E. Huigens

- Infectious parthenogenesis in the Mojave Desert, Haarlem, October 4, 2000

A. van Huis

- Medical and stimulating properties ascribed to arthropods and their products in sub-Saharan Africa. Paris (Villejuif). 3-6 October, 2000.
- Can bugs bring about social change. International Centre of Insect Physiology and Ecology (ICIPE), Nairobi. 16-20 October, 2000 (invited keynote address).

C.H. Koenraadt

- The rise and fall of malaria mosquito populations: results from a field study in Western Kenya. Ede, the Netherlands, 15 December 2000.

J.C. van Lenteren

- From competition, via host discrimination to a multipurpose ovipositor. 25 January 2000, Wageningen.
- Ecologisering van het gewasbeschermings- en vectorziektenonderzoek in de tropen. Voordracht bij het bezoek van Mw. Mr. E.L. Herfkens, Minister van Ontwikkelingssamenwerking en haar staf aan WUR, 1 February 2000, Wageningen.
- A greenhouse without pesticides: rumour or realism? Suwon, Korea, 25 February 2000, (keynote lecture)
- Obtaining large interdisciplinary grants: art or science? Example: Enhanced biodiversity in crop protection. 1 March 2000, Wageningen
- Giorgio Nicoli, entomologist. Memorial meeting 3 March 2000, Bologna, Italy.

  Choice of indicator species for testing non-target effects of pesticides on arthropods, Wageningen , 22 March 2000.
- Enhanced biodiversity for sustainable crop protection a fairy-tale? 11 May 2000, Wageningen
- Data requirements for import and/or commercial inundative release of invertebrate biological control agents. 15-16 May 2000, Wageningen.
- Sustainable production of greenhouse crops without use of pesticides, Perugia, Italy, 15 June 2000.
- Crop protection in sustainable production: ethics and alternatives, Perugia, Italy, 16 June 2000.
- Basis of biological control of arthropod pests, 18-24 June 2000, Zaragoza, Spain
- Evaluating efficiency and quality of natural enemies for biological control, 18-24 June 2000, Zaragoza, Spain
- Whiteflies: bionomics and biological control, 18-24 June 2000, Zaragoza, Spain
- Computer software for decision making in pest and disease control in protected crops, 18-24 June 2000, Zaragoza, Spain
- Insect-plant relationships: the use of plant-resistance for IPM in protected

crops, 18-24 June 2000, Zaragoza, Spain

- Developing IPM: from research to practice, 18-24 June 2000, Zaragoza, Spain.
  How to measure yield loss in relation to insect attack. 25 July 2000, Benin
- Research on farming systems in the Netherlands, collaboration between practice and science. 26 July 2000, Benin

- Augmentation biological control as applied in Latin America, with V.H.P. Bueno. 24 August, Foz do Iguassu, Brazil
- How to find and evaluate natural enemies, 8 September 2000, Berkel and Rodenrijs, Nederland
- Quality Control of Natural Enemies: backgrounds, history and future. 11-15 September 2000, Rotterdam
- Did Antonie van Leeuwenhoek discover insect parasitism? Antonie van Leeuwenhoek Symposium, 1-6 October 2000, Haarlem, The Netherlands
- Future of biological control of pests and diseases in protected cultivation, 16 November 2000, University of Lavras, MG, Brazil
- Mass production of natural enemies, 20 November 2000, University of Lavras, MG, Brazil
- Quality control of natural enemies, 16 November 2000, University of Lavras, MG, Brazil
- Risks of imporation and release of exotic natural enemies, 20 November 2000, University of Lavras, MG, Brazil
- Biological control of pests in Europe, 21 November, University of Lavras, MG, Brazil
- Glasshouse without pesticides: a vision for the future. 5 December 2000, Montreal, Canada
- Biocontrol: risky but necessary. Montreal, Canada. 6 December 2000.
- How to prevent escape of your victim? Ede, 15 December 2000.
- Ecological risks of introducing exotic biocontrol agents into Europe: dispersal abilities and survival in a temperate climate (with A.J.M. Loomans). Ede, 15 December 2000.

A.J.M. Loomans

- Whitefly control in northern Europe: Current State, Constraints, Gaps & Developments. Águilas - Spain, December 8th, 2000 (invited)
- Ecological risks of introducing exotic *Encarsia* species into Europe. Ede – The Netherlands, December 15th, 2000

J.J.A. van Loon

- Evolutie van insect – plant interacties. Rijksuniversiteit Groningen. March 22, 2000 (invited)
- Recognition and response in insect-plant interactions. Wageningen, October 16, 2000 (invited)
- Evolutie van insect-plant interacties. Universiteit van Amsterdam. November 6, 2000 (invited)
- Sampling human odours attractive to the malaria mosquito Anopheles gambiae*. Ede, December 15, 2000.*

E.T.M. Meekes

- Host-plant interaction on fungal infections of insects, Zürich (CH), 28 September 2000.

H.V. Pates

- Mosquitoes are vectors. Boerhaave course "Imported Diseases", 6 June 2000.
- Host selection in An. quadriannulatus is not what it is supposed to be. NEV, 15 December 2000.

R. van Poecke

- Studying indirect defenses using *Arabidopsis thaliana.* University of Toronto, Toronto, Canada 15 May 2000.
- Studying indirect defenses using *Arabidopsis thaliana*. EPS Autumn School, Wageningen, The Netherlands, 16-18 October 2000.

H.M. Smid

- Differences in sexual dimorphism in the antennal lobe of two closely related parasitoid wasps: 3D reconstruction of CLSM images. Lunteren, October 6, 2000.

R. Stouthamer

- Parasitoid popul. and mol. markers. Riverside, USA Feb. 7, 2000 (invited)
- Genomic conflicts, Groningen, The Netherlands, March 13, 2000 (invited)
- Unisexual reproduction in Trichogr. ICIPE Nairobi, Kenya, April 5, 2000 (invited)
- Manipulating microbes in insects, Wageningen, May 18, 2000 (invited)
- Horiz. Transmission of *Wolbachia* in *Trichogramma*, Krete Greece, June 7, 2000
- Genomic conflicts in parasitoid wasps, Groningen, August 30, 2000 (invited)
- Molecular Methods for Quality Control in Natural Enemies, September 14, 2000, IOBC, Berkel-Rodenrijs (invited)Dynamics of sex ratio distorters *in Trichogramma kaykai* field populations, Haarlem, October 4, 2000
- Sex ratio problems in mass rearing, Nairobi, Kenya, October 19th, 2000

W. Takken

- Olfactory discrimination of mosquitoes between host species, Aberdeen University, 12 May 2000.
- Climate change, ecology and human diseases. Iguassu, Brasil, 21 August 2000.
- Understanding of mosquito attraction through identification of volatile compounds emanating from humans. Iguassu, Brasil, 25 August 2000.
- Bednets. What happens to the vector? Amsterdam. 14 November 2000.
- Does insemination affect the host-seeking behaviour of anophelines? Ede, 15 December 2000.

W.F. Tjallingii

- The EPG system and integration aims with video technique. Wageningen, 17 July (invited).
- Can EPG studies help in developing host plant resistance against aphids? Small grain Research Inst., Bethlehem, South Africa.12 September (invited).
- Aphid-plant interactions in phloem sieve elements. Justus Liebig Universitat, Giessen, Germany, 10 October (invited).

- Phloem feeding by aphids. Wageningen, 12 December.

L.E.M. Vet

- Host location by parasitic insects: assessment of profitability through learning. University of Tsukuba, Tsukuba, Japan, October 17 (invited).
- Multitrophic interactions: evolutionary and ecological consequences of plant-carnivore interactions. University of Kyoto, Kyoto, Japan, October 20 (invited).
- Insect parasitoids in multitrophic interactions. University of Kyushu, Kyushu, Japan, October 24 (invited).
- Parasitoids please plants? The evolution of plant-carnivore interactions. University of Kiel, Germany May, 24.
- Pratende planten en slimme sluipwespen. Probus, Bennekom, May 29 (invited)

4 C. POSTERS

S. Boeke

- Toxic and repellent effects of African plants against the cowpea beetle, *Callosobruchus maculatus*. Wageningen 16-18 October, Ede 15 December.

J.G. de Boer

- Variation in odour blend composition: effect on attraction of predatory mites. Wageningen, The Netherlands, 16-18 Oct 2000 (with M. Dicke)

M. Dicke

- Insects in western art. 21 August 2000, Int. Congress of Entomology, Iguassu, Brazil.

C.J.M. Koenraadt

- Larval population dynamics of the vector *Anopheles gambiae* s.l. in western Kenya. Oxford, UK, 18-22 September 2000 (with P. Schneider, A. Githeko & W. Takken)
- The price-tag of a malaria mosquito: results of a socio-economic field study in western Kenya. Ede, The Netherlands, 15 December 2000 (with W. Tuiten, K. Derks, A. Githeko, P. Schneider & W. Takken)

A. Loomans

- Evaluating environmental effects of exotic *Encarsia* species introduced into Europe. Haarlem - the Netherlands, October 1-6th, 2000 (Loomans & Van Lenteren)

H.V.Pates

- Host discrimination of *Anopheles gambiae sensu stricto* and *An. quadriannulatus* between a human and a calf. Oxford 2000. Oxford, UK. 18-22 September 2000. (with W. Takken & C.F. Curtis)

R.M.P. van Poecke

- *Arabidopsis thaliana* produces herbivore-induced volatiles that Attract the Parasitoid *Cotesia rubecula*: Chemical, behavioral and gene-expression analysis. Penn State University, State College, USA, 18-20 May 2000.

W.F. Tjallingii

- Aphid probing events in an anomalous virus transmission. With R.Z. Zhang, Iguacu, Brazil, Int. Congress Entomology, 24 August 2000.

L.E.M. Vet

- Linking above and belowground multitrophic interactions. Van Leeuwenhoek Symposium/European Entomophagous Insects Workshop October 2-6, 2000.
- The Netherlands Institute of Ecology research Poster. NecoV wintermeeting, December 13-14, 2000.

4 D. PUBLICITY

Several events attracted special attention from the public media:

- From January to March, the lecture series 'Insects and Human Society" was held for the 4th time, this year in Leiden in cooperation with the National Museum Naturalis. The lectures attracted ca. 50-80 students and laymen.
- In October the Laboratory of Entomology co-organized the National day on Head Lice in Utrecht. This event attracted much attention from radio, television and newspapers. Several interviews were given, and the event was reported on the TV evening news.

Our research attracted a lot of attention from national and international TV. For instance, the German TV devoted a programme to our research on potato odours induced by Colorado potato beetles that attract carnivorous bugs (Die Sinne der Pflanzen, 23 May 2000). Several programmes covered the topic of 'Insects as human food'. The Brazilian TV paid attention to our research on biological control.

National and international radio and newspaper interviews were given on e.g. nuisance by insects, insects and human culture.

Interviews for TV, radio and newspapers were given by: Dicke, van Huis, van Lenteren, van Loon, Takken, Winkler, Vet

5. STUDENT PROJECTS

5 A. STUDENT THESES

- Baumgart, I.R. 00.08. Laboratory assessment of the efficacy of plant materials for the control of *Callosobruchus Maculatus* (Fab.) in cowpea (*Vigna Unguiculata Walp*).
- Boons, P.A.H., Hollander, R. den, Salverda, M.L.M., 00.31. Distribution of Trichogr. species and their sex ratio in the Mojave Desert.
- Burgmans, J.W.H.A. 00.23. A close observation of an Integrated Pest Management training program (DAE DANIDA SPPS Project) in Bangladesh.
- Burgmans, J.W.H.A. 00.24. Inventarisatie van biologische parameters van een aantal plaaginsecten en biologische bestrijders uit de Nederlandse glastuinbouw.
- Dekker, J. 00.29. Reconstruction of the microsatellite variation in the former Dutch otter population using museum specimens. Gene diversity, bottleneck detection and the origin of a “post extinction” otter.
- Derks, K. 00.11. Malaria in western Kenya. Malaria knowledge of mothers in 3 rural
  villages with year-round, seasonal and unstable malaria transmission resp.
- Dijkstra, P. 00.04. Population dynamics of Wolbachia infection in D. Melanogaster in the
  subtropical region of Australia.
- Dijkstra, P. 00.05a. Interspecific transfer of the paternal sex ratio chromosome in Trichogramma species.
- Dijkstra, P. 00.05b. Transposable elements associated with the Paternal Sex Ratio chromosome in Trichogramma species.
- Dijkstra, P. 00.05c. Phylogeny of the Trichogramma species complex inferred from D2 domain of 28s rDNA.
- Fischer, E.A.J. 00.12. Full Host. The effects of superparasitism on the distribution of two sex ratio distorters through a population of the Trichogramma kaykai.
- Frémont, J. 00.34. Intercropping and pest management: the host plant quality hypothesis.
- Grutters, M. 00.33. Repetitive DNA of the paternal sex ratio chromosome in Trichogramma kaykai.
- Haage, I. 00.15. Odour response of predatory mites *Phytoseiulus persimillis* in a mixed-cropping system Lima bean/cabbage.
- Heerwaarden, J.van. 00.09. Using Internally Transcribed Spacer2 of the rDNA gene complex for separating West African Uscana.
- Heijden, R. van der. 00.19. Occurrence and distribution of Trichogramma species in the Netherlands.
- Herwijnen, Z. van. 00.22. Toetsontwikkeling voor resistentie tegen Florida mineervlieg in diverse groentegewassen.
- Hetebrij, E. 00.17. Kleine beestjes voor een kind. Insecten in kinderboeken. Scriptie Insecten & Maatschappij.
- Klaassen, R.H.G. 99.31/00.18. Microsatellite and AFLP analyses of the Dutch peregrine falcon (*Falcon peregrinus*) population; their origin, individual

recognition and a parent young test.

- Klinkerberg, E. 00.03. The effect of irrigation on the phenology of malaria mosquitoes in the Niger Delta, Mali.

- Lenting, M.J. 00.32. Preferences and performance of *Callosobruchus Maculatus* Fab. (*Coleoptera: Bruchidae)* on pods of various plant species towards natural vegetation manipulation on cowpea production in Benin.
- Maas, M.F.P.M. 00.10. Fitness effects of the paternal sex ratio chromosome in Trichogramma kaykai.
- Mgenzi S.R. Byabachwezi. 00.16. The potential of botanicals in the control of banana weevils (*cosmopolities sorbidus* Germar, Coleoptera: Curculionidae) in Kagera Region Tanzania.
- Pannebakker, B.A. 00.07. Mating structure of Trichogramma Kaykai in natural populations; in preliminary study.
- Reijen, T. 99.16/00.13. Practical internship at CREA. Research Centre for Environmental Agriculture, Cesena Italy.
- Rijswijk, M.E.C. van. 00.01. Occurrence and molecular identification of Dutch Trichogramma species.
- Roodbergen, M. 00.28. Individual recognition of goshawks *Accipites gentills* using microsatellite markers. The pair composition in goshawks.
- Reijnen, T. 00.13. Why does the whitefly parasitoid (*Encarsia Formosa*) feed on its honeydew producing host?
- Schaper, E. 00.38. Virus transmission by the green peach aphid *Myzus persicae.*
- Schenk, M. 00.36. Horizontale en verticale transmissie van Wolbachia bij Trichogramma.
- Schettino, M. 00.26. Observation on mating behaviour and investigation about the existence of a female sex pheromone in the gall midge (*Aphidoletes Aphidimyza*) (Rodani) (*Diptera: Cecidomyiidea*)
- Schilder, R.J. 00.30. Estimating genetic distances between Trichogramma kaykai populations in the Mojave Desert, Califoria, USA.
- Stroom, J.B.P. van der. 00.21. Biological control of *Aulacorthum solani* in sweet pepper: the effectiveness of the French and German line of *Aphelinus Abdominalis* and the hoverfly *Episyrphus balteatus*.
- Stuke, K. 00.06. The role of Fc receptor genotypes and malaria specific antibodies in protection against asexual blood stage *Plasmodium falciparum* in infants.
- Tiase, S.K. 00.02. Spatial oviposition pattern of *Callosobruchus maculatus F.* in stored cowpea (*Vigna unguiculata Walp*).
- Verhulst, N. 00.41. Distinction between the two Trichogramma species T. minutum and T. platneri by mitochondrial analysis.
- Zoltan, I. 00.40. Attracting rosy apple aphid (*Dysaphis plantaginea*) with sex pheromones preliminary experiments.

5 B. Reports on practical internships

- Burgmans, J.w.H.A. A close observation of an Integrated Pest Management training program (DAE DANIDA SPPS Project) in Bangladesh
- Dijkstra, P.D. Population dynamics of Wolbachia infection in D. melanogaster in the subtropical region of Australia.
- Stroom, J. van der. Biological control of Aulacorthum solani in sweet pepper: the effectiveness of the French and German line of Aphelinus abdominalis and the hoverfly Episyrhus balteatus.

5 C. Reports on Insects & Society

- Sweijen, R. Is gifvrije bescherming tegen insecten mogelijk? Scriptie voor Insect & Maatschappij.
- Hetebrij, E. Kleine beestjes voor een kind. Insecten in kinderboeken. Scriptie Insect & Maatschappij
- Vogel, J. de. Insectenkunst. Scriptie voor Insect & Maatschappij.
- Vermeulen, A. Waarheen met de gewasbescherming. Het bestrijden van insecten. Scriptie voor Insect & Maatschappij.

6. REPRESENTATION IN EXTERNAL COMMITTEES

6 A. 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)
- Convenor IOBC/WPRS working group Integrated Pest Management in Protected Cultivation (van Lenteren)
- Convener symposium 'Upcoming model systems' at 9th Int. Symposium on Molecular Plant-Microbe Interactions, A'dam, 25-30 July 1999 (Dicke)
- Coorganizer Sustainable Crop Protection Course 1999, Edinborough, Scotland (EU-Tempus) (van Lenteren)
- Council of the Int. Congress of Entomology (1998-2004) (Takken, member)
- European Union Education Programme 'Sustainable Crop Protection" of the Network of European Agricultural (tropically and subtropically oriented) Universities and scientific complexes Related with Agricultural development (NATURA) of the NATURA European Community Training programme for Agricultural universities in southern Regions. (van Huis, scientific coordinator - implementation)
- FAO Technical Group of the Desert Locust Control Committee (Van Huis)
- Honorary Professor Beijing Normal University (van Lenteren)
- Intern. Working Group on Mediators of Bloodfeeding Arthropods (Takken, secretary)
- Organizer European Parasitoid Workshop 2000, Haarlem (van Lenteren, Kok)
- Scientific Advisory Committee Siconbiol 2001, Brazil (van Lenteren)
- Steering Committee Working Group 'Induced Resistance', International Organization for Biological Control (Dicke)
- International Organisation for Biological and Integrated Control of Noxious Animals and Plants (IOBC-IUBS) (2000-2004) (van Lenteren, Vice President)
- Organisation Comm. International Symposium "Multitrophic Interactions and Environmentally Benign Control of Arthropod Pests", Kyoto, Jan. 2002 (Dicke)
- Organisation Committee and Local Organiser for IOBC workshop 'Induced resistance of plants against pathogens and insects', Wageningen 25-28 April 2001 (Dicke)
- Panel of Experts on Environmental Management of Vectors (PEEM), WHO, Geneva (Takken)
- PhD committees F. Vavre, Universite de Lyon 1, France & H. von der Schulenburg, Cambridge University, UK (Stouthamer)
- PhD committee, T. Leroy, December 21, Université François Rabelais, Tours, France (van Loon)
- 'Professeure associée' at Laval University, Quebec, Canada (Vet)

6 B NATIONAL

- Advisor of Search committee Professor of Animal Ecology RUG (Vet)

- Advisory Board Dutch Health Organization (Adviescommissie Gezondheidsraad) (Schoonhoven, Vet).

6.REPRESENTATION IN EXTERNAL COMMITTEES

- Advisory comm. education programme for Plant Sciences (van Lenteren, Takken)
- Advisory committee on biological fruit growing (Mols).
- Advisory committees and working groups formation of Knowledge Unit Plant Sciences WUR (Dicke, van Lenteren).
- Biologische Raad, KNAW (Vet)
- Board for the Authorisation of Pesticides "CTB" (van Lenteren).
- Board IAC course on crop protection (van Lenteren).
- Board LEB fund (van Lenteren).
- Board of Centre for Ecology, Wageningen University (Vet).
- Board of Institute for Plant Protection (van Lenteren).
- Board of Teaching Institite Life Sciences WU (van Lenteren).
- Board Post Doctoral Course Committee (PHLO): Crop Protection in Glasshouses (van Lenteren).
- Board Post Doctoral Course Committee (PHLO): Modern Crop Protection (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).
- Contact group Behavioural Genetics (Contactgroep Gedragsgenetica; Vet).
- Department of Plant Sciences, Wageningen University, Committee on Strategic Vision (Dicke).
- Department of Plant Sciences, WUR, Committee on Building Affairs (Dicke)
- Dutch Entomological Society (van Lenteren, Vice-president).
- Dutch Entomological Society, Section Experimental and Applied Entomology (SETE-NEV) (van Huis, secretary, Stolk, member).
- Earth and Life Sciences council of the Netherlands Organization for Scientific Research (ALW-NWO) (Vet).
- Earth and Life Sciences council of the Netherlands Organization for Scientific Research (Gebiedsbestuur ALW-NWO) (Vet, member)
- Enhanced biodiversity project , Alterra, Laboratory of Phytopathology, Laboratory of Theoretical Production Ecology (van Lenteren, Vet).
- Gebruikerscommissie ALW-STW project (Vet).
- Graduate School Production Ecology, Scientific Advisory Board, (Vet).
- Graduate School of Production Ecology, Educational Committee (Takken).
- Graduate School of Production Ecology, PhD Student Platform (Meekes)
- Graduate School of Production Ecology, Scientific Committee (van Huis).
- Graduate School Production Ecology (van Lenteren, chairman).
- Integration Platform for the Development of the Wag. Plant Sciences Group ('Kenniseenheid Plant') of Wageningen Univeristy and Research Centre. (Dicke)
- Internal Fire Brigade and First Aid Services, Binnenhaven, Wageningen

University (Dijkman, head).

- Klankbordgroep ‘Avond van de Wetenschap’ (Vet)

6. REPRESENTATION IN EXTERNAL COMMITTEES

- Library Committee, Centre for Crop Protection, Wageningen University (Dicke).
- Member of EU Committee WU: Regulier Overleg Europese Aangelegenheden (van Lenteren).
- National Graduate School 'Experimental Plant Sciences', PhD-students committee (Boeke).
- 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'. Organizing Committee PhD Autumnschool (Dicke, chairman, van Loon, member).
- National Graduate School 'Experimental Plant Sciences'. Scientific Committee (Dicke,).
- NRLO-Coordination Committee Plant Production: Crop Protection (van Lenteren).
- PhD Examination committee F. Van Schoubroek (WU), I. Silva (WU), M. Braks (WU), I. Eijs (RUL, Leiden) (Vet).
- PhD Examination Committee of M. Venzon, M. Bonhof, A. Groot, M. Huijser, M. del Rosario Manzano Martinez (Vet)
- PhD examination committee R.A.F. van den Meiracker, University of Amsterdam (Dicke).
- PhD examination Committee S.Hogenhout, Wageningen University, Wageningen (Stouthamer).
- PhD examination committees national and international (van Lenteren).
- Programme Committee for Curriculum "Plant and Crop Sciences", Wageningen University (Dicke).
- Programme Committee Plant Breeding and Crop Protection (Takken, chairman).
- Programme Committee Plant Sciences, Wageningen University (Takken, member).
- Representative Department for ROC Biology (Dicke, Vet).
- Scientific Committee of the MSc course 'Crop Science' (van Huis).
- Search committee Professor of Plant Ecology, University Nijmegen (Vet).
- Selection Comm. Grant Proposals Renewal Impulse, WUR (Dicke).
- Selection Committee of projects of the Netherlands Foundation for Scientific Research -WOTRO (van Huis).
- Selection committees NWO-personal grants: Pionier, Talent, Puls, Vernieuwingsimpuls etc. (Vet, member)
- Teylers Tweede Genootschap, Teylers Museum, Haarlem (Vet)
- Wageningen UR 'International Development Centre working group" (Meerman)

- Wageningen UR "Acquisition and Marketing working group" (Meerman).

- "Wageningen Crop Protection Centre for Developing Countries", centre without walls composed of the following organizations: Crop Protection and Communication&Innovations Departments of the Wageningen University, Plant Research International (the Research Institute for Plant Protection (IPO) and the Centre for Plant Breeding and Reproduction Research), the Plant Protection Service of the Ministry of Agriculture, Nature Management and Fisheries, the International Agricultural Centre of Wageningen, Agricultural Economics Institute (LEI) (van Huis, chairman).
- "Wageningen Crop Protection International". This Centre is a gateway for the global community to Wagenings' international expertise in pest and crop management. The participating organisations include: Wageningen University (WU), Plant Research International, Agricultural Economics Institute (LEI), the Plant Protection Service (PD) and the International Agricultural Centre (IAC). (van Huis, chairman, Meerman, scientific secretary).
- 2nd Working Group 'Second Moneystream' Wageningen University (Dicke).
- WUR Scenariostudiegroep naar de risico's van de grootschalige toepassing van transgene herbicide-resistente planten (van Loon

6 C. JOURNALS

- Biochemical Systematics and Ecology (Dicke, editorial board).
- Biological Control: Theory and Application in Pest Management (van Lenteren, editorial board).
- Bulletin of Entomological Research (Vet, editorial board).
- Chemoecology (Vet, editorial board).
- Entomologia experimentalis et applicata (van Lenteren, van Loon and Vet, editorial board; Schoonhoven, executive editor).
- Insect Science and its Appl. (van Huis, member 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 Ethology (Dicke, advisory board)
- Journal of Chemical Ecology (Dicke, editorial board).
- Bioch. Systematics and Ecology. Guest editor for special issue on 'Chemical Information Conveyance between Damaged and Undamaged Plants' (Dicke)
- Basic and Applied Ecology. Guest Editor for special issue on 'Induced responses of plants towards herbivory' (Dicke).
- Entomologische Berichten, published by the Dutch Entomological Society, (Dicke, chairman of editorial board)
- Ecological Entomology, editorial board (Dicke)

7. SERVICES

7 A. ADVICE AND OTHER SERVICES

- Visit to FAO HQ and IFAD Rome. Member of a delegation of Wageningen University and Research Centre to investigate possibilities of cooperation in the field of Integrated Pest Management. 24-27 January 2000 (van Huis).
- As consultant for the Directorate General for International Cooperation (DGIS) participation in the Desert Locust Phase II Planning Workshop of the FAO project AEmergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES) in the Central Region. El-tur in the Sinai, Egypt, 26 - 30 March. (van Huis).
- Visit to the Locust and other Migratory Pest Group at FAO Headquarters in Rome to discuss the Netherlands= contribution to the second phase of EMPRES, 25-28 April (A. Van Huis).
- Research Planning Workshop of the FAO/EMPRES project on the Desert Locust in Cairo, Egypt. 11 - 13 November 2000 (van Huis)
- Representative of the Directorate General for International Cooperation (DGIS) at 3rd consultative meeting of the Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases (Desert Locust Component - Central Region), 7-8 December 2000 at FAO, Rome (van Huis).
- Backstopping visit to the project ABiological control of Insect Pests in Subsistence Crops grown by Small-Scale Farmers in Africa (collaborative project of the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi Kenya and the Wageningen Agricultural University, the Netherlands), 3 July, Nairobi (van Huis)
- Backstopping visit as coordinator to the project 'Integrated Pest Management of cowpea', 1-11 August, Cotonou (van Huis)
- Consultancy EPG technique, Small grain Research Inst, Bethlehem, South Africa (Tjallingii).
- Support and supply of information to high-school students (Hoorn, Lelystad, Zeist) and MSc. Students (UK) for writing essays on biological control and ecological risk assessment (Loomans)
- Test site 'Visual Lab', development project of national ministry of enonomic affairs. (Tjallingii)
- Supplying of photographic material for an exhibition on nature conservation composed by Stichting Het Limburgs Landschap (van Loon).

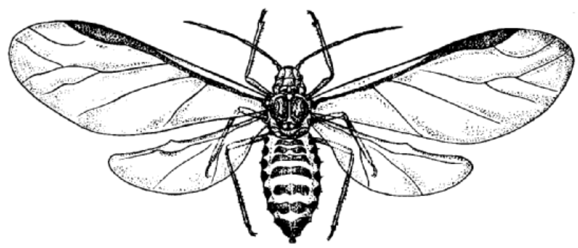
7 B. COURSES/EXCURSIONS

- Course Biological Control, Departement of Entomology, Univ. Lavras, Brazil (van Lenteren, lecturer, 24 March – 9 April 2000)
- International Course on Integrated Pest Management, organized by the International Agricultural Centre, March/April 2000 (van Loon, van Huis, Jongema, van Lenteren)

- International course on Vegetable Production IAC, September 2000 (van Huis, van Lenteren, Jongema)
- 3rd International Course on Agroecology "Biodiversity, food and sustainable development" (van Lenteren, lecturer, 12-17 June 2000, Perugia, Italy)
- Integrated Pest and Disease Management in Protected Cultivation (van Lenteren co-organizer and lecturer, Zaragoza, Spain, 18-24 June 2000)
- PhD course on Biological Control (van Lenteren, lecturer, 16-21November 2000, University of Lavras, MG, Brazil)
- Plant-aphid interactions. Student course (2 weeks) Lab. Pflanzenfysiologie, Giessen, Germany (Tjallingii).

7 C. OTHER

- Referee national and international research proposals (Dicke, van Huis, van Lenteren, van Loon, Meerman, Stouthamer, Vet).
- Referee international journals (Dicke, van Huis, van Lenteren, van Loon, Stouthamer, Takken, Vet).
- Supply of insect material and rearing advice to various people/institutions (Dijkman, Koopman, Wertheim).



8. EXTERNAL CONTACTS

8 A. VISITORS

As in other years, many foreign colleagues, groups of students and also non-entomologists found their way to our Laboratory. Of special importance were the visits of a delegation Chinese Academy of Agricultural Sciences, and of the minister of Developmental Collaboration of The Netherlands. Mrs. Mr. E.L. Herfkens and staff, Minister of Developmental Cooperation, Ministry of Foreign Affairs visited us on 1 February 2000, to discuss projects on Ecological Agriculture in Africa and Asia.

Seminars by visitors 2000:

- Dr. Jennifer Thaler (University of Toronto, Entomology, UC Davis, USA & Botany, Toronto, Canada): Plant resistance mediated interactions across three trophic levels. January 11, 2000.
- Dr. Anurag A. Agrawal (University of Toronto, Entomology, UC Davis, USA & Botany, Toronto, Canada): Induced plant defense: Adaptive plasticity and the next generation. February 8, 2000.
- M. de Courcy Williams (Horticultural Research International): Biocontrol on ornamentals – the beauty and the beasts.
- R. Jacobsen (Horticultural Research International): Meeting challenges in implementing IPM.
- D. Skirvin (Horticultural Research International): Spatio-temporal modelling of tritrophic systems.
- Weeks (University of Amsterdam, Population Biology): Origins and maintenance of asexuality: what can we learn from mites?
- Dr. B. Overholt (ICIPE, Nairobi, Kenya): Ecological consequences of the introduction of *Chilo Partellus* and *Cotesia Flavipes* in Africa.
- Dr. M. Brewer (University of Wyoming, dept of Entomology): Landscape structure and conservation biocontrol: promoting cereal aphid parasitoids in grass-dominant landscapes.
- Dr. W. Foster (Ohio State University, dept. of Entomology, Columbus, Ohio USA): The ambivalent mosquito: plant feeding tactics used by blood-feeding insects.

8 B. CONGRESSES AND SYMPOSIA ATTENDED IN 2000

January

- Cogem Workshop on "Bt toxins and their application in transgenic plants", Wageningen, 31 January 2000. (Dicke)

February

- NIOO-days. 16-17 February 2000 (Vet: introduction, chair, discussion)
- Symposium IPM and biological control. Suwon, Korea 22-27 February 2000. (van Lenteren)

March

- Memorial meeting Giorgio Nicoli. San Giovanni in Persiceto, Italy 2-4 March 2000 (van Lenteren)
- International Workshop on the Abandonment of Persistent Pesticides, Bangkok, Thailand. 6-11 March 2000 (Takken)
- Escort 2 meeting on selection of indicator species and designing testing procedures for non-target effects of pesticides on arthopods (OECD/EPPO/EC/IOBC/BART), Wageningen, 21-24 March 2000. (van Lenteren)
- Symposium NVON 25th anniversary. Wageningen, 24 March 2000 (Dicke)

May

- KNAW/NecoV, Amsterdam, 1 May 2000 (Vet)
- Spring meeting of the Scottish Society of Parasitology. Kindrogan, Scotland. 5-7 May 2000 (Takken)
- NWO-ALW Biodiversity symposium, Wageningen, 11 May 2000 (Vet)
- Meeting OECD/FAO/EPPO/NAPPO/EC/IBMA/ANBP/IOBC: Development and harmonisation of data requirements for invertebrate biological control agents (macrobials), Wageningen, 15-16 May 2000. (van Lenteren)
- The 13th Annual Penn State Symposium in Plant Physiology "Plant Signaling 2000", Penn State Un., State College, USA, 18-20 May'00 (Dicke, v. Poecke)

June

- Boerhaave course “Imported Diseases”, Leiden, The Netherlands. 8- 9 June 2000 (Pates)
- First International Wolbachia meeting, Krete, Greece, 7-12 June 2000. (Stouthamer)

July

- California Conference on Biological Control II, Riverside, California, USA, 11-12 July 2000. (Stouthamer)

August

- XXIst International Congress of Entomology, Iguassu, Brazil, 21-26 August 2000. (Dicke, Groot, Schneider, Silva, Takken, Tjallingii, Wertheim)
- Evolution and ecology of sex. Groningen, 29 August – 2 September 2000. (Stouthamer)

September

- Quality control meeting IBMA, ANBP, IOBC, 11-15 September 2000, Rotterdam. (van Lenteren)
- IOBC quality control meeting, Berkel-Rodenrijs, The Netherlands, September 14, 2000. (Stouthamer)
- Oxford 2000. International Congress of Tropical Medicine, Oxford, UK. 17-23 September 2000 (Koenraadt, Pates, Schneider, Takken)
- Invasive plants and animals: is there a way out? Working Conf. of the Netherlands Comm. for IUCN, The world conservation union. Naturalis, Leiden, 26 September, 2000 (Loomans)
- Cost-meeting: Biological control of pest insects and mites with special

reference to Entomophthorales, EC, Zürich (CH), 28-30 September 2000 (Meekes)

October

- Antonie van Leeuwenhoek Symposium, Haarlem, the Netherlands, October 1-6 2000. (Dicke, Huigens, van Lenteren, Stouthamer, Vet, Wertheim)
- Colloque International “Les Insectes dans la tradition orale”, Villejuif, Paris, 3-6 October, 2000 (van Huis).
- Annual meeting of Graduate School PE&RC, Wageningen, October 11, 2000. (Scholte)
- Autumnschool, Graduate School Experimental Plant Sciences “Interactions between plants and attacking organisms: mechanisms, genetics, ecology and evolution”, Wageningen, 16-18 October 2000. (De Boer, Boeke, Dicke, Groot, Kindt, van Loon, van Poecke)
- Minisymposium on “Interactions among species”. Netherlands Institute of Ecology, Heteren, the Netherlands, 24 October 2000. (Dicke)
- Stemborer workshop, ICIPE, Nairobi, Kenya, 16-20 October 2000. (Stouthamer, Van Huis)
- Landelijk Symposium Neurofysica en Neurobiologie. Lunteren, October 5-6, 2000 (van Loon, Smid, Bleeker).
- 18th Tsukuba Insect Science Symposium. Tsukuba, Japan. Key note speaker, 17 October (Vet)

November

- Daan Mulder Symposium, Amsterdam, The Netherlands, 15 November 2000 (Koenraadt, Pates, Schneider, Scholte, Takken)
- Symposium “Communication: A matter of survival”, BWV Biologica, Wageningen, 15 November 2000. (de Boer, Dicke, Vet-chair, Wertheim)

December

- Entomological Society of America and Canada Meeting, Montreal, Canada,1-7 December 2000. (van Lenteren)
- 12th Annual meeting of Experimental and Applied Entomologists in the Netherlands, Ede, the Netherlands, 17 December 1999. (de Almeida, de Boer, Boeke, Dicke, van Huis, Huigens, Koenraadt, van Lenteren, van Loon, Loomans, , Pates, Smallegange, Takken)
- EPS theme day, theme 2 "Interactions between plants and biotic agents", Graduate School Experimental Plant Sciences, Utrecht 18 December 2000 (Dicke, van Loon, van Poecke)
- NecoV wintermeeting, December 13-14, 2000 (Vet)

8 C. OTHER INTERNATIONAL TRAVEL

M. Dicke

- Institute of Plant Diseases and Plant Protection, University Hannover, Germany, 29 February – 1 March 2000.

A. van Huis

- Search in the National Libraries and libraries of universities and musea in London and Paris for the collection of ethno-entomological information from sub-Saharan Africa, 6-17 March 2000.
- Interviews with personnel, technicians, and students of (1) the Plant Protection Service, the National Agricultural Research Institute, the University, and the Zoological and Botanical Park (Tananarivo, Madagascar), and (2) the Selim Agricultural Research Institute and the GTZ IPM project in Tengeru (Arusha, Tanzania) to collect information on ethno-entomology in sub-Saharan Africa, 27 June - 14 July 2000.
- Interviews with personnel, technicians, and students of Plant Protection Services, National Agricultural Research Institutes, Universities and International Organizations like IITA in Benin, Togo, and Nigeria. to collect information on ethno-entomology in sub-Saharan Africa, 12 August - 2 September 2000.
- Interviews with personnel, technicians, and students of the Plant Protection Service, the National Agricultural Research Institute, and the Universities, both in Yaoundé and in Dchang, Cameroun, to collect information on ethno-entomology in sub-Saharan Africa, 11 - 22 September 2000.

J.C. van Lenteren

- Discuss ERBIC project EC, work on paper ovipositor, discuss Aphidoletes mating behaviour project. 12-18 February 2000. Bologna, Cesena, Perugia, Italy.
- Development of collaborative research and teaching with Univ of Lavras (Brazil), preparation of Siconbiol VII 2001, 24 March – 9 April
- Work on paper ovipositor, discuss Aphidoletes mating behaviour project, Dept Entomology Univ. Perugia, Italy, 17 June 2000
- Backstopping Mission to Benin in the framework of the programme between Benin and The Netherlands: Sustainable Agriculture, Subprogramme Biodiversity and Sustainable Crop Protection, 23-29 July 2000
- Development of collaborative research and teaching with Univ of Lavras (Brazil), preparation of Siconbiol VII 2001, 10-26 November 2000

A.J.M. Loomans

- ERBIC annual evaluation meeting, Istituto di Entomologia 'Guido Grandi', University of Bologna, Bologna, Italy
- European Whitefly Studies Network working groups. 17-18 May 2000, Norwich –UK – Systematics working group
- European Whitefly Studies Network working groups. 06-09 December, 2000, Aguilas – Spain – Biocontrol working group)

J.J.A. van Loon

- Institut de la Recherche sur la Biologie de l'Insecte, Université François Rabelais,

Tours, France. 19-22 December 2000.

H. Pates

- Field study on malaria mosquito research, Jimma, Ethiopia. 20th July- 9th September 2000.

W.Takken

- Fundação Oswaldo Cruz, Rio de Janeiro, Brazil, 7 February 2000.
- Fundação Nacional da Saúde, Porto Velho, Brazil, 8-18 February 2000.
- Fundação Nacional da Saúde, Brasilia, Brazil, 18 February 2000.
- Danish Bilharziosis Laboratory, Copenhagen, Denmark. 3-5 March 2000.
- University of Aberdeen, Aberdeen, Scotland. 1 May – 19 August 2000.
- National Institute of Medical Research, Dar es Salaam, Tanzania. 12-16 June 2000.
- National Institute of Medical Research, Dar es Salaam, Tanzania. 28 October – 2 November 2000.
- Kenyan Institute for Medical Research, Kisumu, Kenya. 2 – 7 November, 2000.
- International Centre of Insect Physiology and Ecology, Mbita Point Station, Kenya. 8-14 November 2000.

8 D. PROJECTS FINANCED EXTERNALLY

- **1998-2000.** Introduction of the gene(s) for zoophily from *Anopheles quadriannulatus* into anthropophilic *An. gambiae sensu stricto* by backcrossing. Funded by WHO-TDR. In cooperation with London School of Hygiene and Tropical Medicine.
- **1996-2001.** Why do drosophilid flies produce volatile aggregation pheromones when it guides parasitoids to their offspring? 1996-2000. Funded by ALW.
- **1998-2001.** Climate change impacts on vector-borne diseases. Funded by National Research Programme on Air Pollution and Climate Change. In cooperation with Maastricht University.
- **1998-2002.** Integrating Geographical Information Systems and Cellular Automata for the Assessment of Malaria Risk and Control. Funded by WOTRO. In cooperation with Maastricht University.
- **1998-2002.** Feeding patterns of African malaria vectors: effect of parasite infection and host (age, sex and olfactory) characteristics. Funded by WU, CDC (Atlanta) and WHO-TDR. In cooperation with KEMRI, Kenya, Centers for Disease Control, Atlanta and ICIPE, Nairobi, Kenya.
- **1998-2002.** Infochemical use by *Typhlodromalus manihoti* and *T. aripo*, two predators of the cassava green mite *Mononychellus tanajoa* in Africa. Funded by IITA, Benin.

- **1998-2002.** Designing improved Desert Locust survey operations and control strategies using scenario studies. This project is executed in the framework of the project "Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases: improvement of Desert Locust survey operations and control strategies" in the Central Region (the countries bordering the Red Sea). This

  project is executed by the Food and Agriculture Organization (FAO) of the United Nations, and funded by the Directorate General for International Cooperation of the Netherlands' Ministry of Foreign Affairs. Wageningen University collaborates with the FAO in carrying out scenario studies for improved Desert Locust survey operations and control strategies. The collaboration consists in developing simulation models for locust survey and control operations.
- **1998-2002.** Genetic variability in *Cotesia flavipes* Cameron and its significance for population establishment in the biological control of lepidopteran stemborers. Funded by WOTRO. In collaboration with ICIPE, Nairobi, Kenya.
- **1998-2002.** Evaluating Environmental Risks of Biological Control Introductions into Europe (ERBIC). Funded by EU FAIR5-CT97-3489 in cooperation with: Department of Applied Zoology, University of Helsinki, Helsinki, Finland; Swiss Federal Research Station for Agroecology and Agriculture, Zürich, Switzerland; CAB International Institute of Biological Control, Silwood Park, Ascot, UK; Istituto di Entomologia 'Guido Grandi', University of Bologna, Bologna, Italy
- **1998-2003.** 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).
- **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 STW.
- **1999-2003** Genomic confl. over sexratios in *Tr.* Wasps. Funded by NOW/ALW
- **2000 - 2003.** Extrafloral nectar in a tri-trophic context. (KNAW fellow).
- **2000 - 2003** *Wolbachia* genome project (EUWOL). Funded by EU
- **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 biodiv. for sustainable crop prot. Funded by NWO/ALW
- **2000 – 2004.** Functional biodiversity: strategic use of nectar and pollen sources to boost biological control. Funded by Robert Bosch
- **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 STW.
- **2000-2004.** Entomopathogenic fungi for biological control of malaria and filariasis vectors on Mfangano island, Lake Victoria, Kenya. Funded by WOTRO.

- **2000-2004.** 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. Funded by IFS, Sweden.
- **2000-2005.** Chemical ecology and management of the banana weevil *Cosmopolites sordidus*. Funded by IITA-Uganda and Rockefeller Foundation..

The Laboratory of Entomology provided technical backstopping to the following projects:
Scientific monitoring of FAO IPM rice project in South and Southeast Asia.

8 E. SCIENTIFIC COOPERATION

8E I. Wageningen University and Research Centre

- Centre for Plant Breeding and Reproduction Research, (CPRO-DLO) Wageningen (Dicke, van Lenteren, van Loon, Tjallingii).
- Laboratory of Genetics (Dicke, van Poecke, Stouthamer).
- Laboratory of Mathematics (Burger, van Lenteren, Stouthamer, Silva, Tjallingii, Vet, Vos, Wertheim).
- Laboratory of Organic Chemistry (Dicke, van Loon, Schoonhoven, Silva, Takken, Vet, Wertheim).
- Centre for Biometry, Wageningen (Wertheim)
- Department of Health Research (Takken)
- Institute for Plant Protection (IPO-DLO), Wageningen (Dicke, van Lenteren, van Loon, Mols, Tjallingii, Vet).
- Laboratory of Phytopathology (Mols, Vet, Wertheim).
- Laboratory of Plant Breeding (van Loon, Tjallingii).
- Laboratory of Theoretical Production Ecology (van Huis, van Lenteren, Mols, Vet).
- Laboratory of Virology (Loomans, Vermunt, Tjallingii)
- Meteorology and Air Quality Group (Takken)

8E II. National

- Bodata Dordrecht (Mols).
- Entocare Biologische Gewasbescherming, Wageningen (Dicke, Gols, Loomans, Schütte)
- Experimental Station for Fruit Production, Wilhelminadorp (Mols).
- Hortibureau Wageningen (Mols).
- International Agricultural Center, Wageningen (van Lenteren, van Huis, Meerman, Stouthamer, Mols)
- Plant Protection Service, Diagnostic Center, Wageningen (Loomans).
- Research Centre for Insect Pollination and Beekeeping "Ambrosiushoeve", Hilvarenbeek. (Boot, Calis).

- University of Amsterdam, Institute of Systematics and Population Biology (Boot, Calis, Dicke, van Lenteren, van Loon, Stouthamer, de Boer).

8.EXTERNAL CONTACTS

- University of Amsterdam, Dept. of Tropical Medicine and Aids (Takken)
- University of Groningen, Dept. of Zoology (Braks, v. Loon, Meijerink,Takken).
- University of Leiden, Institute for Evolutionary and Ecological Sciences, (Dicke, van Lenteren, van Loon, Stouthamer, Vet).
- University of Leiden, Department of Parasitology (Takken).
- University of Nijmegen, Department of Microbiology (Takken).
- University of Utrecht, Section Phytopathology (Dicke, van Poecke).
- Maastricht University, International Centre for Integrative Studies (Takken)
- Netherlands Institute of Ecology (NIOO-KNAW) (Vet)

8 E III. International

- Agriculture Canada Research Station, St-Jean-sur-Richelieu, Quebec, Canada (Vet)
- Aristotle University of Thessaloniki, School of Agriculture, Laboratory of Apiculture and Sericulture, Greece (Boot, Calis).
- Azores University - Dept. Biology, S. Miguel, Azores, Portugal (Silva).
- Bayer AG, Institute for Insect Control, Monheim, Germany (Vet)
- Bee Research and Development Centre, Hanoi, Vietnam. (Boot, Calis).
- Beijing Normal University, Beijing, China (van Lenteren, van Roermund, Tjallingii).
- Biolab, Centrale Orofrutticola, Cesena, Italy (Drost, van Lenteren).
- Biological Control Industries, Sde Elijahu, Israel (Dicke).
- Boyce Thompson Institute for Plant Research at Cornell University, Ithaca, New York, U.S.A. (van Loon).
- CAB International Institute of Biological Control, Silwood Park, Ascot, UK (Loomans)
- Centro de Ciencias Medioambientales, CSIC, Madrid, Spain (Tjallingii)
- Centers for Disease Control, Atlanta, USA (Takken).
- Chinese Academy of Sciences, Zoological Inst. Beijing, PR China (Tjallingii)
- Cornell University, Experimental Station, Geneva, NY, USA (Dicke)
- Département de Formation en Protection des Végétaux (DFPV/CILSS), Niamey, Niger (van Huis).
- Eidgenossische Forschungsanstalt für Obst, Gemüse und Weinbau, Wädenswil, Switzerland (van Loon).
- Eidgenossische Technische Hochschule, Department of Applied Entomology, Zürich, Switzerland (Dicke, Vet).
- Evora University, Department of Biology, Evora, Portugal (van Lenteren, Silva).
- Federal University of Lavras, Brazil (van Lenteren).
- Food and Agriculture Organisation, Plant Protection Service, Rome, Italy. (van Huis).

- Fundação Oswaldo Cruz, Rio de Janeiro, Brazil (Takken).
- Fundação Nacional de Saude, Porto Velho, Brazil (Takken).
- IACR, Rothamsted, Harpenden, U.K (Dicke, Takken, Tjallingii, Vet).
- ICIPE, Nairobi, Kenya (van Huis, Stouthamer, Vet).
- International Institute of Biological Control, Silwood Park, Ascot, UK (Loomans).
- Institut National de la Recherche Agronomique Lyon, Villeurbanne, France (Tjallingii).
- INSA, Laboratoire Biologie Appliquee, Villeurbanne, France (Silva).
- Inst. for Bio Control, Darmstadt, Germany (van Lenteren, Schütte, Silva, Stouthamer).

8.EXTERNAL CONTACTS

- Institute for Crop Protection, Zurich - Reckenholz, Switzerland (van Lenteren, Silva).
- Institut de la Recherche sur la Biologie de l'Insecte, Université François Rabelais, Tours, France. (van Loon).
- Institute of Zoology, University of Neuchatel, Switzerland (Vet).
- Instituto de Investigationes Agropecuarias, Santiago, Chili (Tjallingii).
- International Centre for Insect Physiology and Ecology (ICIPE), Nairobi, Kenya (van Huis, van Lenteren, Stouthamer, Takken, Vet).
- International Institute for Biological Control, Silwood, Ascot U.K. (van Lenteren, van Huis).
- International Institute for Tropical Agriculture, Benin (Dicke, van Huis, van Lenteren).
- Justus Liebig Universität, Giesen, Germany (Tjallingii).
- Keele University, UK (Takken)
- Kenyan Institute for Medical Research, Nairobi, Kenya (Takken).
- Laboratoire de Neurobiologie. CNRS-INRA, Bures-sur-Yvette, France (Vet).
- London School of Hygiene and Tropical Medicine, U.K. (Takken).
- Max Planck Institute of Chemical Ecology, Jena, Germany (Dicke).
- National Institute for Health Research, Indonesia (Takken).
- National Institute for Medical Research, Dar es Salaam, Tanzania (Takken).
- Natural Resources Institute, Chatham, UK (Takken).
- Rheinische Friedrich-Wilhelms-Universität Bonn, Institut für Landwirtschaftliche Zoologie und Bienenkunde, Germany. (Boot, Calis).
- Royal Veterinary & Agricultural University, Chemistry Department, Copenhagen Denmark (van Loon).
- San Jose State University, Department of Biological Sciences, San Jose, California, USA (Silva).
- Small Grains Research Institute, ARC. Bethlehem - Free State, RSA (Tjallingii).
- South African Institute for Medical Research, Johannesburg, S. Africa (Takken).
- Swiss Federal Research Station for Agroecology and Agriculture, Zürich, Switzerland (Loomans).
- Tsukuba Entomological and Ecological Research Institute, Tsukuba, Japan (van Lenteren).

- Universidad de Chile, Quimica Ecologica. Santiago, Chili (Tjallingii).
- Universidad de Cordoba, Facultad de Veterinaria, seccion de Apicultura, Spain (Boot, Calis).
- Universidad de Costa Rica, Museo de Insectos, Costa Rica (Burger).
- Universidade do Algarve - Dept. Fitofarmacologia e Entomologia, Portugal (Silva).
- Universität Halle-Wittenberg, Institut für Zoologie, Halle, Germany (Loomans).
- Université du Bénin, Togo, Laboratoire d'Entomologie Appliquée Faculté des Sciences, Lomé, Togo (Stolk).
- Université National du Bénin, Laboratoire de Biologie Animale, Cotonou, Bénin. (Boeke, Dicke, van Huis, van Lenteren, van Loon, Stolk)

8.EXTERNAL CONTACTS

- Université Laval, Departement de Phytologie , Sainte-Foy, Quebec, Canada (Vet)
- Université, Claude Bernard Lyon-1, Department of Population Genetics, Villeurbanne, France (Stouthamer, Wertheim).
- University of Agriculture and Forestry, Thu Duc, Saigon, Vietnam. (Boot, Calis).
- University of Arizona Department of Ecology and Evolutionary Bio,Tucson, U.S.A. (Vet).
- University of Bologna, Entomological Institute "Guido Grandi", Bologna, Italy (van Lenteren, Loomans).
- University of California at Riverside, Department of Entomology, Riverside, California, U.S.A. (van Lenteren, Stouthamer).
- University College London, Biology, UK (Stouthamer).
- University of Helsinki, Department of Applied Zoology, Helsinki, Finland (Loomans).
- University of Horticultural and Food Industry of Budapest, Hungary, Department of Entomology (van Lenteren, Mols).
- University of Kyoto, Department of Informational Ecology, Kyoto, Japan (Dicke).
- University of Leeds, Department of Microbiology, UK (Takken).
- University of London (UK), Royal Holloway & Bedford New College, Department of Biology, United Kingdom (van Huis, Stolk).
- University of London, Department of Biology, School of Life Sciences, Royal Holloway and Bedford New College (van Huis).
- University of Lund, Department of Ecology, Sweden (Dicke, Vet).
- University of Niamey, Laboratoire de Biologie, Niger (van Huis).
- University of Notre Dame, Indiana, USA (Takken).
- University of Ouagadougou, Laboratory of Entomology and Animal Ecology, Burkina Faso (van Huis)
- University of Rochester, Department of Biology, Rochester, U.S.A. (Stouthamer).
- University of Roma 'la Sapienza', Istituto di Parassitologia (Takken).

- University of Togo in Lomé, 'Laboratoire de Biologie Animale', Togo. (van Huis).
- University of Tours, Inst. de Biocénotique Exp. des Agrosystèmes, France (van Huis).
- University of York, UK (Tjallingii).
- USDA-ARS Midwest Area National Center for Agricultural Utilization Research, Peoria, Illinois, U.S.A. (Dicke, Vet, Wertheim).
- USDA-ARS, Center for Medical, Agricultural and Veterinary Entomology, Gainesville Fl., U.S.A.(Takken).
- USDA-ARS, Insect Biology & Population Management Research Laboratory, Tifton GA, U.S.A. (van Lenteren, Vet).
- Utah State University, Department of Fisheries and Wildlife and Ecological Center, Logan, Utah, USA (Vet). Utah State University, Department of Mathematics and Statistics, U.S.A. (Wertheim).
- Yale University, Dept. of Human Health and Epidemiology, New Haven, CN, USA (van Meer, Stouthamer).
- Institute for Applied Zoology, Free University Berlin, Germany. (Dicke)
- German Collection of Microorganisms and Cell Cultures, Braunschweig, Germany (Schütte)

9. LIST OF PUBLICATIONS 2000

- Abate, T.;Huis, A. van; Ampofo, J.K.O., 2000. Pest management strategies in traditional agriculture: An African perspective. Annual Review of Entomology 45: 631-659.
- Albajes, R.; Lodovica Gullino, M.; Lenteren, J.C. van; Elad, Y., (eds) 1999. Integrated Pest and Disease Managment in Greenhouse Crops. Kluwer Academic Publishers, Dordrecht, 1999. - (Developments in Plant Pathology, 14). - 545 pp.
- Annan, B.; Tingey, W.M.; Schaefers, G.A.; Tjallingii, W.F.; Backus, E.A.; Saxena, K.N., 2000. Stylet penetration activities by *Aphis craccivora* (Hymenoptera: Aphididae) on plants and excised plant parts of resistant and susceptible cultivars of cowpea (Leguminosae). Annals of the Entomological Society of America 93: 133-140.
- Arpaia, S.; Marzo, L. De; Leo, G.M. Di; Santoro, M.E.; Mennella, G.; Loon, J.J.A. van, 2000. Feeding behaviour and reproductive biology of Colorado potato beetle adults fed transgenic potatoes expressing the *Bacillus thuringiensis* Cry3B endotoxin. Entomologia Experimentalis et Applicata 95: 31-37.
- Boff, M.I.C.; Wiegers, G.L.; Gerritsen, L.J.M.; Smits, P.H., 2000. Development of the entomopathogenic nematode *Heterorhabditis megidis* strain NLH-E 87.3 in *Galleria mellonella*. Nematology 2: 303-308.
- Bogya, S.; Marko, V.; Szinetar, C., 2000. Effect of pest management systems on foliage- and grass-dwelling spider communities in an apple orchard in Hungary. International Journal of Pest Management 46: 241-250.
- Bonhof, M.J.; The impact of predators on maize stem borers in coastal

Kenya. Dissertation Wageningen University. Promotor: Dr. J.C. van Lenteren, co-promotor: Dr. ir. A. van Huis. - Wageningen : M.J. Bonhof, 2000. - ISBN 90-5808-262-8. -181 pp.

- Braks, M.A.H.; Scholte, E.J.; Takken, W.; Dekker, T., 2000. Microbial growth enhances the attractiveness of human sweat for the malaria mosquito, *Anopheles gambiae sensu stricto* (Diptera: Culicidae). Chemoecology 10: 129-134.
- Bueno, V.H.P. & J.C. van Lenteren, 2000. Augmentation biological control as applied in Latin America. In Abstract book of the XXIth International Congress of Entomology, Foz do Iguassu, Brazil, 20-26 August: 369.
- Bukovinszky, T, L.E.M. Vet, V. Rasztik, J.C. van Lenteren & G. Bujaki, 2000. Effects of different intercropping systems on herbivores and their natural enemies. Proceedings of the 46th Plant Protection Days, Hungarian Academy of Sciences: 47.
- Burgio, G.; Lenteren, J.C. van; Ferrari, R.,1999. Indagine sui parassitoidi e predatori di afidi su colture erbacee dell'Emilia-Romagna. (The complex of parasitoids and predators of arable crops in Emilia-Romagna region). Italus Hortus 6: 43.
- Cherqui, A.; Tjallingii, W.F., 2000. Salivary proteins of aphids, a pilot study on identification, separation and immunolocalisation. Journal of Insect Physiology 46: 1177-1186.
- Ciociola, A.I., Almeida, R.P. de, Stouthamer, R., 2000. Does degradation of DNA
in dead *Trichogramma* individuals lead to failure of their identification using ITS2 PCR? Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society 11: 33 – 36.

- Cuartero, J.; Laterrot, H.; Lenteren, J.C.; 1999. Host-plant resistance to pathogens and
  arthropod pests.
  In: Integrated pest and disease management in greenhouse crops. In: R. Albajes, M. Lodovica Gullino, J.C. van Lenteren & Y. Elad (eds.). Dordrecht : Kluwer Academic Publishers: 124-138.
- Curtis, C.F.; Pates, H.V.; Takken, W.; Maxwell, C.A.; Myamba, J.; Priestman, A.; Akinpelu, O.; Yayo, A.M.; Jiang Ting Hu, 1999. Biological problems with the replacement of a vector population by *Plasmodium*-refractory mosquitoes. Parassitologia 41: 479-481.
- Dicke, M., 2000. Heksenjacht op gentechnologie onnodig. Agrarisch Dagblad, 06-01-2000:
- Dicke, M., 1999. Biologische bestrijding van plagen: planten zijn doe-het-zelvers (deel 2). Gewasbescherming 30 (2): 33-36.
- Dicke, M., 1999. Book review: Evolutionary patterns and mechanisms in consumer-resource interactions. Vertical Food Web Interactions: Evolutionary Patterns and Driving Forces. K. Dettner, G. Bauer & W. Volkl (eds.) Springer Verlag, Berlin. Journal of Evolutionary Biology 12: 419-420
- Dicke, M., 2000. Chemical ecology of host-plant selection by herbivorous arthropods: a multitrophic perspective. Biochemical Systematics and Ecology 28: 601-617.
- Dicke, M., 2000. Book review. Pheromones of non-lepidopteran insects associated with agricultural plants. J. Hardie & A.K. Minks (eds.) CABI Press, Wallingford, 1999, 466 pp. Entomologia Experimentalis et Appl. 96: 89-90.
- Dicke, M.; Schütte, C.;Dijkman, H., 2000. Change in behavioral response to herbivore-induced plant volatiles in a predatory mite population. Journal of Chemical Ecology 26: 1497-1514.
- Dicke, M.; Loon, J.J.A. van, 2000. Multitrophic effects of herbivore-induced plant volatiles in an evolutionary context. Entomologia Experimentalis et Applicata 97: 237-249.
- Drost, Y.C., Y.T. Qiu, C.J.A.M. Posthuma-Doodeman & J.C. van Lenteren, 2000. Comparison of searching strategies of five parasitoid species of *Bemisia argentifolii* Bellows & Perring (Homoptera: Aleyrodidae). Journal of Applied Entomology 124: 105-112.
- Dijk, H.F.G. van; Brussaard, L.; Stein, A.; Baerselman, F.; Heer, H. de; Brock, T.C.M.; Donk, E. van; Vet, L.E.M.; Gaag, M.A. van der; Gestel, C.A.M. van; Hoeven, N. van der; Jong, F.M.W. de; Linden, A.M.A. van der; Noort, P.C.M. van; Oomen, P.A.; Vliet, P.J.M. van, 2000 Veldonderzoek voor de toelating van gewasbeschermingsmiddelen. Gewasbescherming 31: 136-139.
- Dijk, H.F.G. van; Brussaard, L.; Stein, A.; Baerselman, F.; Heer, H. de; Brock, T.C.M.; Donk, E. van; Vet, L.E.M.; Gaag, M.A. van der; Gestel, C.A.M. van;
- Hoeven, N. van der; Jong, F.M.W. de; Linden, A.M.A. van der; Noort, P.C.M. van; Oomen, P.A.; Vliet, P.J.M. van, 2000. Field Research for the Authorisation of Pesticides. Ecotoxicology 9: 377 – 381.

9. LIST OF PUBLICATIONS 2000

- Etienne, R.; Wertheim, B.; Hemerik, L.; Schneider, P.; Powell, J., 2000. Dispersal may enable persistence of fruit flies suffering from the Allee effect and scramble competition. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society N.E.V. 11: 121-128.
- Geervliet, J.B.F.; Verdel, M.S.W.; Snellen, H.; Schaub, J.; Dicke, M.; Vet, L.E.M., 2000. Coexistence and niche segregation by field populations of the parasitoid *Cotesia glomerata* and *C. rubecula* in the Netherlands: predicting field performance from laboratory data. Oecologia 124: 55-63
- Groot, A.T.; Timmer, R.; Gort, G.; Lelyveld, G.P.; Drijfhout, F.P.; Beek, T.A. van;Visser, J.H.; 1999. Sex-related perception of insect and plant volatiles in *Lygocoris pabulinus.* Journal of Chemical Ecology 25: 2357-2371.
- Groot, A.T.; Wal, E. van der; Schuurman, A.; Visser, J.H.; Blommers, L.H.M.; Beek, T.A. van; 1998. Copulation behaviour of *Lygocoris pabulinus* under laboratory conditions. Entomologia Experimentalis et Applicata 88: 219-228.
- Groot, A.T., 2000. Sexual behaviour of the green capsid bug Dissertation, Wageningen Universiteit. Promotor: Prof.Dr. M. Dicke, co-promotor: Dr. J.H. Visser. - Wageningen : A.T. Groot, 2000. - ISBN 90-5808-268-7, 156 pp.
- Grostal, P.; Dicke, M., 2000. Recognising one's enemies: a functional approach to risk assessment by prey. Behavioral Ecology and Sociobiology 47: 258-264.
- Gullino, M.L.; Albajes, R.; Lenteren, J.C. van, 1999. Setting the stage : characteristics of protected cultivation and tools for sustainable crop protection. In: Integrated pest and disease management in greenhouse crops. R. Albajes, M. Lodovica Gullino, J.C. van Lenteren & Y. Elad (eds). Kluwer Academic Publishers, Dordrecht: 1-15.
- Hemerik, L.; Harvey, J.A., 1999. Flexible larval development and the timing of destructive feeding by a solitary endoparasitoid : an optimal foraging problem in evolutionary perspective. Ecological Entomology 24: 308 – 315.
- Harvey, J.A.; Jervis, M.A.; Gols, R.; Jiang, N.; Vet L.E.M., 1999. Development of *Cotesia rubecula* (Hymenoptera: Braconidae) in *Pieris rapae* and *P. brassicae* (Lepidoptera: Pieridae): evidence for host regulation. Journal of Insect Physiology 45:173-182.
- Harvey, J.A., 2000. Dynamic effects of parasitism by an endoparasitoid wasp on the development of two host species : implications for host quality and parasitoid fitness. Ecological Entomology 25: 267-278.
- Helden, M. van; Tjallingii, W.F., 2000 Experimental design and analysis in EPG experiments with emphasis on plant resistance research. In: G.P.Walker and E.A.Backus (eds.) Principles and applications of electronic monitoring and other techniques in the study of homopteran feeding behavior. Thomas Say Publications in Entomology, Entomological Society of America, Lanham, MD, p. 144-171.
- Hoffland, E.; Dicke, M.; Tintelen, W. van; Dijkman, H.; Beusichem, M.L., 2000.

Nitrogen availabilty and defense of tomato against two-spotted spider mite. Journal of Chemical Ecology 26: 2697-2711.

- Huigens, M.E.; Luck, R.F.; Klaassen, R.H.G.; Maas, M.F.P.M.; Timmermans, M.J.T.N.; Stouthamer, R., 2000. Infectious parthenogenesis. Nature 405: 178-179.

9. LIST OF PUBLICATIONS 2000

- Ignacimuthu, S.; Wäckers, F.L.; Dorn, S.; 2000. The role of chemical cues in host finding and acceptance by *Callosobruchus chinensis*. Entomologia Experimentalis et Applicata 96: 213-219.
- Jiang, N.; Xu, R.; Lenteren, J.C. van; Roermund, H.J.W. van, 1999. Temporal and spatial analysis of greenhouse whitefly and its parasitoid *Encarsia formosa* in two types of greenhouse ecosystems. Journal of Applied Entomology 123: 547-554.
- Kraker, J. de; Huis, A. van; Heong, K.L.; Lenteren, J.C. van; Rabbinge, R., 1999. Population dynamics of rice leaffolders (Lepidoptera: Pyralidae) and their natural enemies in irrigated rice in the Philippines. Bulletin of Entomological Research 89: 411-421.
- Kraker, J. de, R. Rabbinge, A. van Huis, J.C. van Lenteren, K.L. Heong, 1999. Impact of nitrogenous-fertilization on the population dynamics and natural enemies of rice leaffolders (Lep.: Pyralidae). International Journal of Pest Management 46: 225-235.
- Kraker, J. de, A. van Huis, J.C. van Lenteren, K.L. Heong, & R. Rabbinge, 2000. Identity and relative importance of egg predators of rice leaffolders (Lepidoptera: Pyralidae). Biological Control 19: 215 – 222.
- Krips, O.E.; Plant effects on biological control of spider mites in the ornamental crop Gerbera. Dissertation, Wageningen Universiteit. Promotoren: Prof.Dr. M. Dicke, Prof. Dr. M.W. Sabelis, Prof.Dr. J.C. van Lenteren. Wageningen, O.E. Krips, 2000. - ISBN: 90-5808-188-5. 113 pp.
- Lei, H.; Lenteren, J.C. van; Tjallingii, W.F., 1999. Analysis of resistance in tomato and sweet pepper against the greenhouse whitefly using electrically monitored and visually observed probing and feeding behaviour. Entomologia experimentalis et applicata 92: 299-309.
- Lenteren, J.C.; Manzaroli, G., 1999. Evaluation and use of predators and parasitoids for biological control of pests in greenhouses. In: Integrated pest and disease management in greenhouse crops . In: R. Albajes, M. Lodovica Gullino, J.C. van Lenteren & Y. Elad (eds). Dordrecht : Kluwer Academic Publishers: 183-201.
- Lenteren, J.C. van; Martin, N.A., 1999. Biological control of whiteflies In: Integrated pest and disease management in greenhouse crops. In: R. Albajes, M. Lodovica Gullino, J.C. Lenteren & Y. Elad (eds). - Dordrecht : Kluwer Academic Publishers: 202-216.
- Lenteren, J.C. van; Tommasini, M.G., 1999. Mass production, storage, shipment and quality control of natural enemies. In: Integrated pest and disease mangement in greenhous crops. R. Albajes, M., Lodovica Gullino, J.C. van

- Lenteren & Y. Elad (eds). - Dordrecht : Kluwer Academic Publishers, 1999: 276-294.
- Lenteren, J.C. van, 2000. A greenhouse without pesticides : rumour or realism ? In: Proceedings of the International Symposium on Biological control for Crop Protection, 24-25 February 2000, Suwon, Korea. Rural Development Administration, no.11, 1999: 117-133.
- Lenteren, J.C. van; Loomans, A., 2000. Biologische bestrijding : altijd goed ? Agrarisch Dagblad 08.02.2000: 1

- Lenteren, J.C. van; Isidoro, N.;Romani, R.;Bin, F., 1999. The multipurpose ovipositor of *Leptopilina heterotoma* : relationships between form and function. In: Atti dell'Academia Nazionale Italiana di Entomologia. Rendiconti XLVII: 265-275.
- Lenteren, J.C. van; Loomans, A.J.M., 2000. Biological control of insects: always safe ? Risks of introduction and release of exotic natural enemies. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society N.E.V. 11: 3-21.
- Lenteren, J.C. van, 2000. A greenhouse without pesticides: fact or fantasy? Crop Protection 19: 375-384.
- Lenteren, J.C. van, 2000. Criterios de selecao de inimigos naturais a serem usados em programas de controle biologico In: Controle biologico de pragas: Producao massal e controle de qualidade. In: Bueno, V.H.P. (ed.) - Lavras, Brasil : Universidade Federal de Lavras (UFLA), 2000.- p. 1-19.
- Lenteren, J.C. van, 2000. Controle de qualidade de agentes de controle biologico produzidos massalmente : conhecimento, desenvolvimento e diretrizes. In: Controle biologico de pragas: Producao massal e controle de qualidade. Bueno, V.H.P. (ed.)- Lavras, Brasil : Universidade Feceral de Lavras (UFLA): 21-43.
- Loomans, A.J.M.; Heijboer, A.; 1999. *Franklinothrips vespiformis* (Crawford): a polyphagous predator preying on thrips eggs. Proceedings Experimental & Applied Entomology, N.E.V. 10: 143-150.
- Loon, J.J.A. van; Vos, E.W. de; Dicke, M., 2000. Orientation behaviour of the predatory hemipteran *Perillus bioculatus* to plant and prey odours. Entomologia Experimentalis et Applicata 96: 51-58.
- Loon, J.J.A. van, de Boer, J.G. & Dicke, M., 2000. Parasitoid-plant mutualism: parasitoid attack of herbivore increases plant reproduction. Entomologia Experimentalis et Applicata 97: 219-227.
- Lotz, L.A.P.; Brussaard, L.; Gillissen, L.J.W.J.; Gorissen, A.; Kempenaar, C.; Loon, J.J.A. van; Noordam, M.Y.; Termorshuizen, A.J.; Vliet, P.C.J. van, 2000. Effecten van grootschalige toepassing van transgene herbicideresistente rassen : Ontwikkeling en verkenning van scenario's. Wageningen : Wageningen UR Plant Research International - 2, 110 pp.
- Manzano, M.R.; Lenteren, J.C. van; Cardona, C.; Drost, Y.C., 2000. Developmental time, sex ratio and longevity of *Amitus fuscipennis* MacGown & Nebeker (Hymenoptera: Platygasteridae) on the greenhouse whitefly. Biological Control 18: 94-100.
- Manzano Martinez, M.R., 2000. Evaluation of *Amitus fuscipennis* as biological control agent of *Trialeurodes vaporariorum* on bean in Colombia. Dissertation, Wageningen Universiteit. Promotor: Dr. J.C. van Lenteren. - Wageningen: M.R. Manzano, 2000. - ISBN 90-5808-312-8. - 149 pp.
- Mboera, L.E.G.; Takken, W.; Sambu, E.Z., 2000. The response of *Culex quinquefasciatus* (Diptera: Culicidae) to traps baited with carbon dioxide, 1-octen-3-ol, acetone, butyric acid and human foot odour in Tanzania. Bulletin

of Entomological Research 90: 155-159.

- Mboera, L.E.G.; Takken, W.; Mdira, K.Y.; Chuwa, G.J.; Pickett, J.A., 2000. Oviposition and behavioral responses of *Culex quinquefasciatus* to skatole and synthetic oviposition pheromone in Tanzania. Journal of Chemical Ecology 26: 1193-1203 .
- Mboera, L.E.G.; Takken, W.; Mdira, K.Y.; Pickett, J.A., 2000. Sampling gravid *Culex quinquefasciatus* (Diptera: Culicidae) in Tanzania with traps baited with synthetic oviposition pheromone and grass infusions. Journal of Medical Entomology 37: 172-176.
- Mboera, L.E.G.; Knols, B.G.J.; Braks, M.A.H.; Takken, W., 2000. Comparison of carbon dioxide-baited trapping systems for sampling outdoor mosquito populations in Tanzania. Medical and Veterinary Entomology 14: 257-263.
- Meekes, E.T.M.; Voorst, S. van; Joosten, N.N.; Fransen, J.J.; Lenteren, J.C. van, 2000. Persistence of the fungal whitefly pathogen, *Aschersonia aleyrodis*, on three different plant species. Mycological Research 104: 1234-1240.
- Meijerink, J.; Braks, M.A.H.; Brack, A.A.; Adam, W.; Dekker, T.; Posthumus, M.A.; Beek, T.A. van; Loon, J.J.A. van, 2000. Identification of olfactory stimulants for *Anopheles gambiae* from human sweat sample. Journal of Chemical Ecology 26: 1367-1382.
- Mele, P. van, 2000. Evaluating farmers' knowledge, perceptions and practices: a case study of pest management by fruit farmers in the Mekong Delta, Vietnam. Dissertation Wageningen Universiteit. Promotor: dr. J.C. van Lenteren, co-promotor: dr. A. van Huis. - Wageningen : P. Van Mele, 2000. - ISBN 90-5808-267-9.–229pp.
- Mele, P. van; Cuc, N.T.T., 2000. Evolution and status of *Oecophylla smaragdina* (Fabricius) as a pest control agent in citrus in the Mekong Delta, Vietnam. International Journal of Pest Management 46: 295-301.
- Messchendorp, L.; Gols, G.J.Z.; Loon, J.J.A. van, 2000. Behavioural observations of *Pieris brassicae* larvae indicate multiple mechanisms of action of analogous drimane antifeedants. Entomologia Experimentalis et Applicata 95: 217-227.
- Metsaars, M.A.J.; Takken, W.; Meer, G. de, 2000. Hoofdluisinfecties en het falen van anti-hoofdluismiddelen in Nederland. Tijdschrift voor Gezondheidswetenschappen 78: 401-405.
- Mols, P.J.M., 2000. Simulation approach of the role of the pine ladybird (*Exochomus quadripustulatus* L.) and the earwig (*Forficula auricularia* L.) in controlling the woolly apple aphid (*Eriosoma lanigerum* Haussmann). Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society N.E.V. 11: 129-134.
- Ofomata, V.C.; Overholt, W.A.; Huis, A. van; Egwuatu, R.I., 2000. Comparative studies on the fecundity, egg survival, larval feeding, and development of *Chilo partellus* and *Chilo orichalcociliellus* (Lepidoptera: Crambidae) on five grasses. Annals of the Entomological Society of America 93: 492-499
- Parrella, M.P.; Stengard Hansen, L.; Lenteren J.C. van, 1999. Glasshouse

environments. In: Handbook of Biological Control. Principles and Applications of Biological Control. T.S. Bellows, T.W. Fisher, L.E. Caltagirone, D.L. Dahlsten, G. Gordh, C.B. Huffaker. - London : Academic Press. ISBN 0-12-257305-6: 819-839.

9. LIST OF PUBLICATIONS 2000

- Potting, R.P.J.; Vermeulen, N.E.; Conlong, D.E., 1999. Active defence of herbivorous hosts against parasitism: Adult parasitoid mortality risk involved in attacking a concealed stemboring host. Entomologia experimentalis et applicata 91: 143-148.
- Reese, J.C.; Tjallingii, W.F.; van Helden, M.; Prado, E., 2000 Waveform comparison among AC and DC electronic monitoring systems for aphid (Homoptera, Aphididae) feeding behavior. In: G.P.Walker and E.A.Backus (eds.) Principles and applications of electronic monitoring and other techniques in the study of homopteran feeding behavior. Thomas Say Publications in Entomology, Entomological Society of America, Lanham, MD, p. 70-101.
- Roda, A.;Nyrop, J.; Dicke, M.; English-Loeb, G., 2000. Trichomes and spider-mite webbing protect pred. mite eggs from intraguild predation. Oecologia 125: 428-435.
- Roermund, H.J.W. van; Lenteren, J.C. van, 1998. Simulation of whitefly biological control, based on behaviour of individual Parasitoids. In: Population and Community Ecology for Insect Management and Conservation. 20th International Congress of Entomology, The Ecology and Population Dynamics Section, Florence 1996. J. Baumgartner, P. Brandmayr, B.F.J. Manly (eds.). A.A. Balkema, R'dam/Brookfield:175-182.
- Romeis, J.; Wäckers, F.L.; 2000. Feeding responses by female *Pieris brassicae* butterflies to carbohydrates and amino acids. Physiological Entomology 25: 247-253.
- Sampaio, M.V., V.H.P.Bueno & J.C. van Lenteren, 2000. Host preference of *Aphidius colemani* Viereck (Hymenoptera: Aphididae) for *Myzus persicae* (Sulzer) and *Aphis gossypii* Glover (Hemiptera: Aphididae). In: Abstract book of the XXIth International Congress of Entomology, Foz do Iguassu, Brazil, 20-26 August: 415.
- Schneider, P.; Takken, W.; McCall, P.J., 2000. Interspecific competition between sibling species larvae of *Anopheles arabiensis* and *An. gambiae.* Medical and Veterinary Entomology 14: 165-170.
- Schuilenburg, J.H.G. van de; Hurst, G.D.D.; Huigens, T.M.E.; Meer, M.M.M. van; Jiggins, F.M.; Majerus, M.E.N., 2000. Molecular evolution and phylogenetic utility of Wolbachia ftsZ and wsp gene sequences with special reference to the origin of male-killing. Molecular Biology and Evolution 17: 584-600.
- Shimoda, T.; Dicke, M., 2000. Attraction of a predator to chemical information related to nonprey: when can it be adaptive? Behavioral Ecology 11: 606-613.
- Silva, I.M.M.S.; Meer, M.M.M. van; Roskam, M.M.; Hoogenboom, A.; Gort, G.;

Stouthamer, R., 2000. Biological control potential of *Wolbachia*-infected versus uninfected wasps: Laboratory and greenhouse evaluation of *Trichogramma cordubensis* and *T. deion* strains. Biocontrol Science and Technology 10: 223-238.

- Sommen, A.T.C. van der; Wertheim, B.; Vet, L.E.M.; Dicke, M., 2000. The attraction of *Drosophila busckii* by substrate and aggregation pheromone under laboratory conditions. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society N.E.V. 11: 189-194.
- Spittel, M.C.; Huis, A. van, 2000. Effect of cassava mosaic disease, soil fertility, plant spacing and their interactions on cassava yields in Zanzibar. International Journal of Pest Management 46: 187-193.

9. LIST OF PUBLICATIONS 2000

- Stouthamer, R.;Luck, R.F., 2000. Wolbachia-induced parthenogenesis. In: International Symposium on Alternative Reproduction strategies, November 25-28, 1999. - Shonan-Kokusai Mura : The Graduate University for Advanced Studies Shonan-Kokusai Mura, Hayama, Japan, 1999. - (Journal of Reproduction and Development 46 (supplement): 19-20.
- Stouthamer, R.; Gai, Y.; Koopmanschap, A.B.; Platner, G.R.; Pinto, J.D., 2000. ITS-2 sequences do not differ for the closely related species *Trichogramma minutum* and *T. platneri*. Entomologia Experimentalis et Applicata 95: 105-111.
- Stouthamer, R.; Jochemsen, P.; Platner, G.R.; Pinto, J.D., 2000. Crossing incompatibility between *Trichogramma minutum* and *T. platneri* (Hymenoptera: Trichogrammatidae): Implications for application in biological control. Environmental Entomology 29: 832-837.
- Sütterlin, S., 2000. Biological control of whitefly on Gerbera: success or failure ? Tritrophic interactions between *Gerbera jamesonii, Trialeurodes vaporariorum and Encarsia formosa.* Dissertation Wageningen Universiteit. Promotor: Dr. J.C. van Lenteren, co-promotor: Dr.ir. J.J. Fransen. - Wageningen : S. Sütterlin, 2000. - ISBN 90-5808-324-1. 177 pp.
- Sütterlin, S.; Lenteren, J.C. van, 2000. Pre- and post-landing response of the parasitoid *Encarsia formosa* to whitefly hosts on *Gerbera jamesonii*. Entomologia Experimentalis et Applicata 96: 299-307.
- Takabayashi, J.; Dicke, M.; Posthumus, M.A.; Takahashi, S., 1999. Inter and intraspecific variation in composition of herbivore-induced synomones that attract predatory mites. In: Acarology IX, Proceedings 9th International Congress of Acarology, G.R. Needham, R. Mitchell, D.J. Horn & W.C. Welbourn (eds.). - Ohio Biological Survey, Columbus Ohio: 239-244.
- Takabayashi, J.; Shimoda, T.; Dicke, M.; Ashihara, W.; Takafuji, A., 2000. Induced response of tomato plants to injury by green and red strains of *Tetranychus urticae.* Experimental and Applied Acarology 24: 377-383.
- Takken, W.; Eling, W.; Hooghof, J.; Dekker, T.; Hunt, R.; Coetzee, M., 1999. Susceptibility of *Anopheles quadriannulatus* Theobald (Diptera: Culicidae) to *Plasmodium falciparum.* Transactions of the Royal Society of Tropical

- Medicine and Hygiene 93: 578-580.
- Takken, W., 2000. Book Review: The biology of mosquitoes Vol. 2 - Sensory Reception and behaviour by A.N. Clements. CABI Publishing, Wallingford, UK. Entomologia Experimentalis et Applicata 94: 217.
- Takken, W.; Mboera, L.E.G., 2000. Effects of chemical stimuli on oviposition of *Culex quinquefasciatus* (Diptera: Culicidae) in Tanzania. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society N.E.V. 11: 181-187
- Takken, W., 2000. Malaria mosquitoes favor human skin and not expired air. International Journal of Dermatology 39: 180-181.

- Tchuanyo, M.; Huis, A. van; Lenteren, J.C. van, 2000. Distribution, incidence and abundance of the cassava brown root scale insect, *Stictococcus vayssierei*, in Cameroon. Tropical Science 40: 20-24.
- Tjallingii, W.F., 2000. Comparison of AC and DC systems for electronic monitoring of stylet penetration activities by homopterans. In: G.P.Walker and E.A.Backus (eds.) Principles and applications of electronic monitoring and other techniques in the study of homopteran feeding behavior. Thomas Say Publications in Entomology, Entomological Society of America, Lanham, MD, p. 41-69.
- Tjallingii, W.F.; Zhang, R.Z., 2000. Aphid probing events in an anomalous virus transmission. In: Abstract book of the XXI International Congress of Entomology, Foz do Iguassu, Brazil, p. 818.
- Weissbecker, B.; Loon, J.J.A. van; Posthumus, M.A.; Bouwmeester, H.J.; Dicke, M., 2000. Identification of volatile potato sesquiterpenoids and their olfactory detection by the two-spotted stinkbug *Perillus bioculatus*. Journal of Chemical Ecology 26: 1433-1445.
- Wertheim, B.; Sevenster, J.G.; Eijs, I.E.M.; Alphen, J.J.M. van, 2000. Species diversity in a mycophagous insect community: the case of spatial aggregation vs. resource partitioning. Journal of Animal Ecology 69: 335-351.