FINAL REPORT

Project Number:	PC100b
Project Title:	Attendance of 1993 International Conference on Thysanoptera
Project Leader:	R J Jacobson
Location of Project:	Horticulture Research International Stockbridge House Cawood Selby North Yorkshire YO8 OTZ Tel: 0757 268275 Fax: 0757 268996
Project Coordinator:	A Shirley
Report Date:	December 1993
Date Project Commenced:	27 August 1993
Date Completed:	30 November 1993
Key Words:	International Conference, Western Flower Thrips, Biology, Behaviour, Control Measures, Ornamentals, Cucumbers

A REPORT TO THE HORTICULTURAL DEVELOPMENT COUNCIL
18 LAVANT STREET, PETERSFIELD, HANTS, GU32 3EW

ATTENDANCE OF 1993 INTERNATIONAL CONFERENCE ON THYSANOPTERA

Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature ....R Jacobson....

R Jacobson
Project Leader

Date ..6/1/94........

Report authorised by ....G.M. Tatchell......... (signature)

Dr M Tatchell
Head of Entomology
HRI Wellesbourne
Warwick
CV35 9EF

Date ...10.1.94........

CONTENTS

	page
SUMMARY SECTIONS	
1. Brief Summary	5
2. Extended Summary	5
FULL REPORT	
1. Conference details	7
2. Objectives	7
3. Background	7
4. Conference participants	8
5. Details of conference proceedings	8
6. Technical content of conference	9
6.1. Papers and poster presentations	9
6.2. Other information of specific interest	9
6.2.1. General biology and behaviour	9
6.2.2. Transmission of Tomato Spotted Wilt Virus.	11
6.2.3. Control measures	11
6.2.4. Other topics	13
7. Acknowledgements	13
Appendix 1 - Conference programme	14
Appendix 2 - List of delegates	18
Appendix 3 - Names and addresses of speakers	21
Appendix 4 - List of posters	24
Appendix 5 - Compilation of abstracts of relevant poster manuscripts	28
Appendix 6 - Compilation of abstracts of relevant papers available the time of preparation of this report	41

SUMMARY SECTIONS

1. Brief Summary

The 1993 International Conference on Thysanoptera was a gathering of thrips specialists from around the world who reported their recent work on the biology, behaviour, taxonomy, ecology and control of various important thrips pests.

Attendance at the conference provided a unique opportunity to meet these specialists and establish foundations upon which future working relationships could be developed.

UK growers now have the benefit of access to information presented both formally and informally at this conference, and to the knowledge and expertise of the participants.

2. Extended Summary

Although the UK horticultural industry leads the world in many aspects of the implementation of integrated pest management (IPM) in protected crops, the programmes in ornamentals and cucumbers are still unreliable. This is largely due to the difficulties of controlling western flower thrips (WFT). To improve the systems it is necessary to increase the knowledge of the fundamental biology and behaviour of the pest so that weak points in its life cycle can be identified and exploited.

The 1993 International Conference on Thysanoptera was a gathering of thrips specialists from around the world who reported their recent work on the biology, behaviour, taxonomy, ecology and control of various important thrips pests.

The objectives of attending this conference were :

1. To establish contact with research scientists working on relevant aspects of thrips biology and behaviour in other countries.

2. To pave the way for future liaison with these scientists.

3. To obtain up to date, unpublished information on biology and behaviour of thrips.

4. To contribute to discussions on integrated pest management (IPM) of Western Flower Thrips (WFT), and exchange information with a view to refining our own control strategy.

5. To accept the conference organising committee's invitation to present a paper entitled "Do greenhouse growers have resources to implement biological control properly?"

6. To present a poster entitled "Egg laying sites of the thrips predator *Orius majusculus* on cucumber crops".

Initial contact was made with key individuals and the way prepared to develop future working relationships with them. This benefit is difficult to pass on to non-participants but the following information is provided in the full HDC report so that growers can, if they wish, make direct contact with the research workers:

1. List of conference delegates and organisations represented
2. List of papers presented
3. Names and addresses of all speakers
4. List of posters presented
5. Names and addresses of presenters of relevant posters

A vast quantity of technical information on many thrips species and a wide variety of host plants was presented at the conference. Full manuscripts of all papers and posters will be compiled by the conference organisers in a book to be published in 1994. Growers can be guided to relevant topics in that publication by the lists of papers and posters provided in the full report. Advance copies of abstracts of the presentations considered to be of most interest are also included, if they are available at this stage.

Much valuable information was revealed during discussion periods which will probably not appear in the proceedings. The most relevant is summarised briefly in the full report under the sub-headings:

1. General biology and behaviour of WFT
    - i). Overwintering
    - ii). Pupation sites
    - iii). Feeding
    - iv). Male behaviour

2. Transmission of tomato spotted wilt virus

3. Control measures
    - i). Resistant cultivars of cucumbers
    - ii). Alarm pheromones
    - iii). Ceranisus spp. parasites
    - iv). Pathogenic fungi
    - v). Attractants
    - vi). Amblyseius spp.
    - vii). Plant alkaloids

4. Other topics
    - i). Spread of disease
    - ii). Insecticide resistance
    - iii). Predatory thrips

The practical value of the information is not always obvious at this stage but may prove important as more knowledge becomes available and the pieces of the puzzle begin to fit together.

Knowledge of research projects underway elsewhere will help to avoid duplication of effort and stimulate new ideas within our own R & D programmes.

FULL REPORT

1. CONFERENCE DETAILS

Title:	The 1993 International Conference on Thysanoptera. (A NATO Advanced Research Workshop).
Venue:	University of Vermont, Burlington, Vermont, USA.
Date:	28-30 September 1993 - Conference 1 October 1993 - Supplementary Workshop
Organising Committee:	Bruce L. Parker (Conference coordinator) Trevor Lewis Carl C. Childers Bruce S. Heming Michael P. Parella Margaret Skinner
Programme:	See Appendix 1

2. OBJECTIVES

It is impossible to predict the knowledge which will be gained by attending a conference but the following general objectives were agreed in advance:

1. To establish contact with research scientists working on relevant aspects of thrips biology and behaviour in other countries.

2. To pave the way for future liaison with these scientists.

3. To obtain up to date, unpublished information on biology and behaviour of thrips.

4. To contribute to discussions on integrated pest management (IPM) of Western Flower Thrips (WFT), and exchange information with a view to refining our own control strategy.

5. To accept the conference organising committee's invitation to present a paper entitled "Do greenhouse growers have resources to implement biological control properly?"

6. To present a poster entitled "Egg laying sites of the thrips predator *Orius majusculus* on cucumber crops".

3. BACKGROUND

WFT remains the most serious pest of UK horticulture. It causes particular difficulties for the cucumber and ornamental industries.

Growers in other parts of Europe have access to two pesticides (abamectin and methiocarb) which are effective against WFT. In the absence of any such chemical in the UK, growers are striving to perfect biological, physical and cultural methods of control. The UK is currently at the world forefront of the implementation of some of these techniques but the programmes are still unreliable and growers continue to suffer serious production losses.

To improve the IPM systems it is necessary to increase our understanding of the pests fundamental biology and behaviour so that weak points in its life cycle can be identified and exploited. Knowledge of this subject is currently poor. There has been little relevant information published and no detailed studies are currently in progress in the UK.

The 1993 International Conference of Thysanoptera offered a unique opportunity to meet research scientists from all over the world and to share with them the latest developments in thrips biology, behaviour and control.

4. CONFERENCE PARTICIPANTS

The conference was attended by over 180 scientists from 26 nations. A full list of delegates and the organisations they represent is included in Appendix 2. The worlds leading Thysanopterists, including Prof.T.Lewis, Prof.L.A.Mound, Prof.R.zur Strassen, Dr.B.Heming, Dr.G.Moritz and Dr.S.Nakahara, were present.

Initial contact was made with all the key individuals, and foundations laid upon which future working relationships can be developed. It is difficult to pass on this benefit to non-participants but I have included details of names and addresses of useful contacts in Appendices 2 and 5, and I will be pleased to assist with preliminary introductions.

5. DETAILS OF CONFERENCE PROCEEDINGS

Full manuscripts of all papers and posters presented at the conference will be compiled in a book to be published in 1994:

TITLE: Towards understanding thrips management.

EDITORS: Bruce L. Parker, Margaret Skinner and Trevor Lewis.

PUBLISHERS: Plenum Publishing Corp.

6. TECHNICAL CONTENT OF CONFERENCE

It is beyond the scope of this document to report the entire technical content of the conference; that is the function of the conference proceedings. The role of this document is to ensure that HDC members are aware of the subjects covered and to highlight topics which may be of particular interest. If more detailed information is required members should obtain a copy of the Proceedings or contact the relevant research worker. Where possible I will be pleased to provide assistance.

6.1. Papers and Poster Presentations

Approximately two thirds of the 36 papers presented were devoted to thrips biology, behaviour, taxonomy and ecology. The remainder covered many varied aspects of IPM. Titles of papers are listed in Appendix 1 and the names and addresses of speakers are provided in Appendix 3. Copies of papers considered of most interest to UK growers have been requested from the authors. Those available have been compiled in Appendix 6. Each paper was followed by a discussion period in which the subjects were critically assessed. It was during these full and open discussions that some of the most useful unpublished information came to light.

In addition to the papers, 60 posters were on view. This provided delegates who were not speaking formally with the opportunity to present details of their recent work. The poster viewing session also proved to be an extremely efficient means of identifying delegates who had common scientific interests. A full list of posters is provided in Appendix 4. Each one was accompanied by a brief manuscript, and a compilation of those considered of most interest to UK growers is provided in Appendix 5.

Although WFT was only one of many thrips species on the agenda, its worldwide importance ensured that it received much attention throughout the conference.

Several presentations included details of experimental techniques which may be modified for our own use.

6.2. Other information of specific interest

The following notes summarise information extracted largely from discussion periods which may not feature in the conference proceedings. The practical value of the information is not always obvious at this stage but may prove important as more knowledge becomes available and the pieces of the puzzle begin to fit together.

6.2.1. General Biology and Behaviour

There has been no definitive study of WFT biology and behaviour but many delegates had first hand experience of the pest in a

wide variety of crops and were able to provide well informed comment :

i). Overwintering

WFT is generally considered to have no true diapause. Adult females overwinter in a quiescent form from which they quickly emerge when temperatures rise. Studies into cold hardiness of WFT have shown females to be more resilient than pupae, though in practice pupae may overwinter in less vulnerable locations.

If females are repeatedly brought out of the quiescent stage without an opportunity to feed they probably exhaust their body reserves and may reabsorb their eggs. Their chance of surviving in a fertile state is therefore poorer under fluctuating temperatures around freezing than at a constant lower temperature which holds them in the quiescent state. It may therefore be advantageous to warm empty greenhouses periodically through the winter period. However, more information is required to determine the critical temperature thresholds.

A very dark coloured biotype of WFT, which is thought to be an outdoor overwintering stage, has been reported in several countries although not yet in the UK. It could easily be mistaken for cereal thrips on a sticky trap and therefore may have been overlooked on commercial nurseries.

Onion thrips have been shown to overwinter successfully on wheat plants and it is quite possible that WFT can do the same. In the UK, reinvasion from this source would be unlikely before late April.

ii). Pupation Sites

WFT pupation is still poorly understood. It appears to pupate in different sites depending on the insect strain, host plant, growth habit of host plant and time of year. The factors which influence whether they pupate in situ on the plant, drop to the floor, or walk to a suitable crevice on the plant must be studied in detail.

Prof Trevor Lewis invited delegates to write to him with further information. He would then prepare a "review" of the subject.

iii). Feeding

Papers by Mound, Kirk and Childers refer to the diversity of WFT food material and to the physical mechanism of feeding.

WFT have been shown to supplement their diet through predation and cannibalism.

Thrips damage to plant cells causes a release of ethylene which is an attractant to the predator, **Orius spp.**

iv). Male behaviour

In warmer climates male WFT are known to aggregate outdoors in the early season, usually on white, yellow or blue structures. This is consistent with observations on sticky traps in UK glasshouses and suggests more attention should be given to trapping as a control measure at specific times of year.

Terry described a fighting ritual common in groups of male WFT prior to mating. There is evidence of different morphological forms which show aggressive and passive behaviour.

6.2.2. Transmission of Tomato spotted wilt virus (TSWV)

Ullman described the interaction between WFT and TSWV at a cellular level. An understanding of these events will provide a foundation for management strategies to limit TSWV spread, such as production of transgenic plants that will block both thrips acquisition and inoculation of the virus, and new assays for detecting viruliferous thrips populations.

A defence mechanism which is activated within the insect cells after acquiring the virus can be fatal and many thrips do not survive to pass it on.

Both Ullman and Broadbent described immunological tests for TSWV, including variability in results. It is particularly difficult to correlate the results with visual symptoms on the plant. A technique now exists to detect the virus in WFT and it is even possible to determine whether the insect acquired it as an adult or larvae. The latter is important because the virus can only be transmitted when acquired in the larval stage.

6.2.3. Control measures

i). Resistant cultivars of cucumbers

Cucumber cultivars which exhibit resistance to WFT are currently in development in The Netherlands. Thrips survival has been reduced by up to 80% on the most promising cv's with the second larval stage most affected. This could become an important part of the IPM programme by slowing down the pests development while predators are becoming established. The most resistant cv's are now included in commercial breeding programmes.

ii). Alarm pheromones

Two chemicals which act as alarm pheromones have been identified in exudates from WFT larvae and synthesized. Their presence causes agitation, cessation of feeding and some larvae to drop from the leaf prematurely. The latter could enhance the effect of polybutene based floor treatments.

iii). *Ceranisus spp.* parasites

There are now various species in culture in Japan and The Netherlands. The parasite attacks very young WFT and usually has a short life cycle but the pupal stage may be prolonged for up to 200 days. The reasons for this are not yet understood but it currently limits the parasites potential as a control agent.

iv). Pathogenic fungi

The application of pathogenic fungi with electrostatic sprayers has improved control in some outdoor crops by 50%. Similar benefits may be obtained in protected crops although the charged droplets could be attracted to parts of the structure and plastic floor covering.

Various adjuvants and formulations are being tested with a view to enhancing the effect of pathogenic fungi; for example, formulations prepared for use against desert locusts have remained stable for over a year.

Studies are underway to identify and select strains of pathogenic fungi which will germinate and infect insects at lower relative humidity than current commercial products.

A project is starting in Vermont which will investigate the interaction between *V.lecanii* and beneficial arthropods. A preliminary agreement has been made to include the strains of parasites and predators commonly used in the UK in that study.

v). Attractants

Incorporation of anisaldehyde in water traps is reported to increase the number of WFT caught by 50%. There could be potential to develop this technique as a control measure, particularly at low insect population densities in ornamental crops.

vi). *Amblyseius spp.*

Non-diapausing strains of *A.cucumeris*, which are claimed to be more effective in the early season than the standard commercial products, are being reared in The Netherlands.

A.degenerans is reported to breed successfully at lower relative humidity than *A.cucumeris*, and to be a more effective predator. However, it is not known to be native to the UK and cannot therefore be released in our crops.

A.degenerans does not perform well in the culture sachets developed for *A.cucumeris* but its performance has been enhanced by spraying pollen suspensions onto cucumber plants.

vii). Plant alkaloids

Many plant taxa have evolved highly sophisticated chemical defense systems against insects, mites, pathogens and even weeds. Knowledge of the secondary plant metabolites (particularly alkaloids) with insecticidal properties is improving and there is potential for control mechanisms based on extracted or synthesised chemicals, use of toxic trap plants, or by gene transfer to crop plants.

6.2.4. Other topics

i). Spread of disease

Viable spores of plant pathogens have been extracted from the gut of various thrips species and germinated successfully. This implies that thrips could be involved in the spread of plant disease.

ii). Insecticide resistance

Strains of WFT from around the UK have shown up to 20 fold and 3 fold differences in tolerance to dichlorvos and malathion respectively. This is not a widespread problem, nor has any particular pattern been observed, but it is a cause for concern because they are the two most useful insecticides available against this pest in the UK.

iii). Predatory thrips

A number of thrips species predate upon other insects and mites. One in particular, the six spotted thrips, is a useful predator of spider mites in outdoor crops in the USA. It has proved difficult to rear in culture but measures can be taken to encourage the natural population. Unfortunately, it is not known to be native to the UK.

7. ACKNOWLEDGEMENTS

I am grateful to the Humberside WFT Study Group for supporting my attendance at the conference, and to the HDC, NATO (via the conference organising committee) and HRI for providing funds.

APPENDIX I:

CONFERENCE PROGRAMME

1. **BACKGROUND BIOLOGY**

(Session Leader: Trevor Lewis)

1.1 **Thrips as phytophagous opportunists.**
Laurence A. Mound & David A. J. Teulon

1.2 **Reproduction in Thysanoptera**
Bruce S. Heming

1.3 **Morphogenetic development of some species of the order Thysanoptera**
Gerald Moritz

1.4 **Round Table Discussion: Thrips Biology**
Trevor Lewis, Laurence A. Mound, Bruce S. Heming & Gerald Moritz

2. **PHYTOPHAGY AND ITS EFFECTS**

(Session Leader: Joseph R. Chamberlin)

2.1 **Feeding behaviour and nutritional requirements**
William D. J. Kirk

2.2 **Thrips feeding and oviposition injuries to economic plants, subsequent damage and host responses to infestations.**
Carl C. Childers & Diann S. Achor

2.3 **Thrips transmission of *Tospoviruses*: Future possibilities for management**
Diane E. Ullman, T. L. German, J. S. Sherwood & D. M. Westcot

(Session Leader: E. Alan Cameron)

2.4 **Effects of interactions within the western flower thrips/tomato spotted wilt virus/host plant complex on virus epidemiology**
A. Bruce Broadbent & Wayne R. Allen

2.5 **Impact of pear thrips damage on sugar maple physiology: A whole tree experiment**
David S. Ellsworth, Melvin T. Tyree, Bruce L. Parker & Margaret Skinner

2.6 **Genotypic effects of cucumber responses to infestation by western flower thrips**
Chris Mollema, Greet Steenhuis & Hein Inggamer

3. **POPULATION BIOLOGY AND ECOLOGY**

(Session Leader: Margaret Skinner)

3.1 **Competition in western flower thrips males: Effects of density on behaviour**
L. Irene Terry

3.2 **Six-spotted thrips: a gift from nature that provides control**
Frank E. Gilstrap

3.3 **Local adaptation by thrips to individual plant clones: Effects of dispersal and reproduction**
Sharon Y. Strauss & Richard Karban

(Session Leader: Carl W. Fatzinger)

3.4 **Population diversity of Thysanoptera in meadows**
Liliana Vasiliu-Oromulu & Bela Tothmeresz

3.5 **Temporal and spatial dynamics of thrips populations in a diverse ecosystem: Theory and management**
Anthony M. Shelton

3.6 **The biology and chemical ecology of western flower thrips**
Colleen Teerling

4. **PEST DISTIBUTION AND CROP INFESTATIONS**

(Session Leader: Jennifer A. Grant)

4.1 **The importance of thrips management: A grower's perspective**
Peter Konjoian

4.2 **Thysanoptera of quarantine significance: International movement and detection**
Gijsbertus Vierbergen

4.3 **Monitoring of western flower thrips on glasshouse and vegetable crops**
J. Les Shipp

(Session Leader: N. S. Talekar)

4.4 **Bionomics of cotton thrips**
Thomas F. Leigh

4.5 **A technique for mass rearing even-aged western flower thrips (Thysanoptera: Thripidae)**
Eva Noronha Doane, Bruce L. Parker & Yvon Pivot

4.6 **Colonization and population dynamics of thrips in peanut agroecosystems**
James W. Todd, A. K. Culbreath & Joseph R. Chamberlin

5. **BIOLOGICAL CONTROL**

(Session Leader: Ernest S. Delfosse)

5.1 **Do greenhouse growers have the resources to implement biological control properly?**
Robert J. Jacobson

5.2 **Mycopathogens for thrips management: Myth or reality?**
Michael Brownbridge

5.3 **The host-parasite interaction between *Frankliniella occidentalis* (Thysanoptera: Thripidae) and *Ceranisus menes* (Hymenoptera: Eulophidae): Development and reproduction.**
Tamotsu Murai & Antoon J. M. Loomans

5.4 **On binomial data of some predacious thrips**
Richard zur Strassen

5.5 **Marketing considerations for biological controls**
Marilyn Y. Steiner

5.6 **The ethics of introducing exotic biological control agents**
Ernest S. Delfosse

5.7 **Biological control using oligophagous predators**
Pierre M. J. Ramakers

5.8 **Electron microscopic studies of the infection process of *Verticillium lecanii* on *Frankliniella occidentalis*.**
Gerd Schreiter, Gerald Moritz & M. Trost

5.9 **The beneficial component of thrips populations: An example of their impact on spider mites in California cotton**
Daniel Gonzalez, Rex Friesen, Thomas Leigh & L. P. Wilson

6. INTEGRATED PEST MANAGEMENT

(Session Leader: Manes Wysoki)

6.1 **IPM - approaches and prospects**
Michael P. Parrella

6.2 **Managing citrus thrips pesticide resistance**
Joseph G. Morse

6.3 **IPM of *Thrips palmi* in vegetables**
Marshall W. Johnson

(Session Leader: Bruce L. Parker)

6.4 **Western flower thrips in peach and nectarine in France: Consequences on IPM**
Dominique Grasselly, Gilles Perron & Eric Navarro

6.5 **IPM in glasshouses**
Gerard W. Ferrentino

APPENDIX II:

LIST OF CONFERENCE PARTICIPANTS

Australia

Goodwin, Stephen: Hort. Res. & Advisory Sta.
Houlding, Bronwyn: W.A. Dept. of Agriculture
Monzu, Nic: W.A. Dept. of Agriculture

Belgium

Gerin, Celile: Université Catholiqué de Louvain

Brazil

França, Félix H.: EMBRAPA - CNPH

Canada

Allen, Wayne R.: Agriculture Canada
Broadbent, A. Bruce : Agriculture Canada
Bergh, Chris: Nova Scotia Agricultural College
Chiasson, Hélène: Agriculture Canada
Dutton, Ron: Univ. of Guelph
Fournier, Francois: Agriculture Canada
Gelinas, Louis: Laval Univ.
Hardy, Christine: Laval Univ.
Heming, Bruce S.: Univ. of Alberta
Maw, Eric: Agriculture Canada
Pearsall, Isobel A.: Univ. of British Columbia
Shipp, J. Les: Agriculture Canada
Steiner, Marilyn: Alberta Environmental Center
Teerling, Colleen: Univ. of New Brunswick

Colombia

Amador, Julio: Floramerica S.A.
Astaiza Valencia, Rodrigo: Floramerica S.A.

Denmark

Brødsgaard, Henrik: Institute of Plant & Soil Sci.
Vestergaard, Susanne: Chr. Hansens BioSystems

Ethiopia

Demisie, Ababu: Inst. of Agricultural Research
Gebre-Amlak, Assefa: Awassa College of Agric.

Finland

Lindquist, Isa : Agricultural Research Center

France

Grasselly, Dominique: CTIFL
Guillon, Michel: Calliope

Germany

Moritz, Gerald: Martin-Luther-Universität
Schreiter, Gerd: Martin-Luther-Universität
zur Strassen, Richard : Forschungsinst. Senckenberg

Greece

Roditakis, Nikos: Plant Protection Institute

India

Lakshmi, K. Vijaya: ICRISAT

Israel

Ben-Dov, Yair: The Volcani Center
Izhar, Yehonatan: Dept. of Agriculture
Klein, Meir: The Volcani Center
Wysoki, Manes: The Volcani Center

Italy

Addante, Rocco: Università di Bari
Marullo, Rita: Univ. degli Studi della Basilicata
Moleas, Teodoro: Università di Bari

Japan

Haga, Kazua: Univ. of Tsukuba
Murai, Tamotsu: Shimane Agric. Exp. Sta.

Philippines

Barrion, Alberto: Intl. Rice Research Institute

Portugal

Frescata, Carlos: Inst. Superior de Agronomia
Mateus, Célia: Inst. Superior de Agronomia

Romania

Vasiliu-Oromulu, Liliana: Academia Română

South Africa

Badenhorst, Jacqui: Univ. of Stellenbosch
Zeier, Peter : Instituut vir Groente en Sierplante

Spain

Beitia, Francisco J.: C.I.T. - I.N.I.A.
Riudavets, Jordi: IRTA

Sweden

Olsson, Christer: Swedish Board of Agriculture

Taiwan

Chang, Niann-Tai : Natl. Pingtung Polytech. Inst.
Talekar, N.S.: AVRDC Taiwan
Wang, Chin-Ling: Taiwan Agric. Research Inst.

Thailand

Bansiddhi, Kobkiati : Department of Agriculture
Poonchaisri, Sirinee: Department of Agriculture

Conference Participants (cont.)

The Netherlands

de Jager, C. M.: Univ. of Leiden
Loomans, Antoon J.M. : Wageningen Agric. Univ.
Mollema, Chris: CPRO
Peters, Dick: Wageningen Agricultural Univ.
Ramakers, Pierre M.J. : Glasshouse Crops Res.
van de Klashorst, Gerrit: Univ. of Amsterdam
van Dijken, Folchert R.: CPRO
van Rijn, Paul C.J. : Univ. of Amersterdam
van Houten, Yvonne M.: Glasshouse Crops Res.
Vierbergen, Gijsbertus: Ministerie van Landbouw

United Kingdom

Jacobson, Robert: HRI, Stockbridge House
Kirk, William D.J.: Keele Univ.
Lewis, Trevor: Inst. of Arable Crops Res.
Mound, Laurence A.: Natural History Museum
Walters, Keith: Central Science Laboratory

United States

Achor, Diann S.: Citrus Research & Ed. Center
Adamowicz, Alek: Univ. of Vermont
Adamowicz, Renate: Univ. of Vermont
All, John N.: Univ. of Georgia
Alverson, David: Clemson Univ.
Amalin, Devina: Univ. of Vermont
Andersen, Eric: Brooklyn Bot. Gardens Corp.
Anderson, Thomas E.: BASF Corporation
Armstrong, Colleen: Univ. of Vermont
Baranowski, Richard M.: Univ. of Florida
Barton, Bernard: VT Dept. of Forests, Parks & Rec.
Black, William E.: Mycotech Corporation
Boone, James: Univ. of Vermont
Bradley, Jay: Whitmire Research Labs
Broda-Hydorn, Susan: USDA, APHIS, PPQ
Brownbridge, Michael: Univ. of Vermont
Burns, Barbara D. : VT Dept. of Forests, Parks & Rec.
Cameron, E. Alan: The Pennsylvania State Univ.
Cartwright, Bob: Oklahoma State Univ.
Casey, Millie: Ohio State Univ.
Chamberlin, Joseph R.: Yoder Brothers, Inc.
Childers, Carl C.: Univ. of Florida
Cloutier, Conrad: Laval Univ. Canada
Cloyd, Raymond: Purdue Univ.
Cole, Charles L.: Texas A&M Univ.
Coli, William: Univ. of Massachusetts
David, Paul J.: American Cyanamid Company
Delfosse, Ernest S.: Natl. Biological Control Inst.
Denmark, Harold: FL Division of Plant Industry
Doane, Eva N.: Univ. of Vermont
Eckel, Craig: North Carolina State Univ.
Ellsworth, David: Univ. of Vermont,
Fatzinger, Carl W.: Southeast Forest Exp. Stn.
Fazli, Syed F.: Trop. Amer. Agric. Consulting Serv.
Felland, Carl M.: The Pennsylvania State Univ.
Ferrentino, Gerard W.: Cornell Univ.
Forcier, Lawrence K.: Univ. of Vermont
Foster, Michael A.: The Pennsylvania State Univ.
Frantz, Galen E.: Glades Crop Care, Inc.
Garcia, Lloyd: North Carolina Dept. of Agric.
Gill, Stanton: Univ. of Maryland
Gilstrap, Frank. E.: Texas A & M Univ.
Glenister, Carol: IPM Laboratories, Inc.
Glenn, Holly B.: Univ. of Florida
González, Daniel: Univ. of California
Grafton-Cardwell, Beth: Univ. of California
Grant, Jennifer A.: NYSAES - Cornell Univ.
Greene, Ian D. : Univ. of California
Grehan, John: Univ. of Vermont
Hanson, Patricia: VT Dept. of Forests, Parks & Rec.
Hartman, Mary Anne: Whitmire Research Labs
Hollingsworth, Craig: Univ. of Massachusetts
Humber, Richard : USDA, ARS
Hunter, Wayne B.: USDA, ARS
Johnson, Marshall W.: Univ. of Hawaii
Kelley, Ronald S.: VT Dept. of Forests, Parks & Rec.
Kingsley, Philip C.: USDA, APHIS
Kresta, Kenya: Texas Agricultural Experiment Station
LaRosa, Steve: Univ. of Vermont
Leigh, Thomas F.: Univ. of California
Leskey, Tracy C.: The Pennsylvania State Univ.
Linnane, James P.: USDA, Forest Service
Lopes, Paul: Cranberry Experiment Station
Lord, Jeffrey: Ecoscience Corp.
Lowry, Virginia K. : Texas A & M Univ.
Mack, Ronald: Univ. of Maine
Maier, Chris T.: Conn. Agricultural Experiment Station
Matteson, Nancy A.: Univ. of Idaho
Mena, Jaime: Univ. of Maine
Mitchell, Forrest : Texas Agric. Experiment Station
Morse, Joseph G.: Univ. of California
Nakahara, Sueo: USDA, ARS
Negasi, Adhanom: Univ. of Vermont
Newman, Julie: Univ. of California
Nuessly, Gregg: Univ. of Florida
Oraze, Michael J.: National Biological Control Institute
Ouyang, Yuling: Univ. of California
Parker, Bruce L.: Univ. of Vermont
Parrella, Michael P.: Univ. of California
Phillips, Phil A.: Univ. of California
Puche, Helena : Univ. of Florida
Reed, Jack T.: Mississippi State Univ.
Reed, Gaylord: Vermont Dept. of Forests, Parks & Rec.
Reith-Rozelle, Judith: Agracetus
Rieske, Lynne: Univ. of Wisconsin
Robb, Karen: Univ. of California
Sargent, Tom: Univ. of Vermont
Seal, Dakshina R.: Univ. of Florida
Shelton, Anthony M.: NYSAES - Cornell Univ.
Skinner, Margaret: Univ. of Vermont
Smith, Tina M.: Univ. of Massachusetts
Smitley, David: Michigan State Univ.
Souto, Dennis: USDA, Forest Service
Spellman, Martin R.: Univ. of Delaware
Stack, Philip A.: Univ. of Maine
Steward, V. Bruce: Longwood Gardens
Strauss, Sharon Y.: Univ. of Illinois
Teillon, H. Brenton: VT Dept. of Forests, Parks & Rec.
Terry, Irene: Univ. of Utah
Teulon, David A. J.: The Pennsylvania State Univ.
Tjosvold, Steve: Univ. of California
Toapanta, Marco: Univ. of Florida
Tobi, Donald R.: Univ. of Vermont
Todd, J. W.: Univ. of Georgia
Trjapitzin, Serguey V.: Univ. of California
Ullman, Diane E.: Univ. of Hawaii
Wilmot, Sandra: VT Dept. of Forests, Parks & Rec.

APPENDIX III:

NAMES AND ADDRESSES OF SPEAKERS AT THE 1993 INTERNATIONAL CONFERENCE ON THYSANOPTERA

Speakers at the 1993 International Conference on Thysanoptera

Dr. A. Bruce Broadbent
Agriculture Canada
P.O. Box 6000 Vineland Station
Ontario LOR 2EO
CANADA
Tel: 416-562-4113 Fax: 416-562-4335

Dr. Michael Brownbridge
University of Vermont
Entomology Research Laboratory
655B Spear Street
South Burlington, VT 05403
Tel: 802-658-4453 Fax: 802-658-7710

Dr. Carl C. Childers
Univ. of FL
Citrus Research & Education Center
700 Experiment Station Road
Lake Alfred, FL
33850
Tel: 813-956-1151 Fax: 813-956-4631

Dr. Ernest Delfosse
USDA National Biological Control Institute
6505 Belcrest Dr.
Hyattsville, MD 20782
Tel: 301-436-4329 Fax: 301-436-7823

Ms. Eva Noronha Doane
University of Vermont
Entomology Research Laboratory
655B Spear Street
South Burlington, VT 05403
Tel: 802-658-4453 Fax: 802-658-7710

Dr. David Ellsworth
Department of Botany
University of Vermont
Burlington, VT 05405
Tel: 802-656-0680
Fax: 802-656-2914

Mr. Gerard Ferrentino
49B Plant Science
Cornell Univ.
Ithaca, NY
14853
Tel: 607-255-5918 Fax: 315-

Dr. Frank E. Gilstrap
Department of Entomology
Texas A & M University
College Station, TX
77843
Tel: 409-845-7958 Fax: 409-847-8668

Dr. Daniel González
Entomology Department
University of California
Riverside, CA
92521
Tel: 909-787-5711 Fax: 909-787-3086

Ir. Dominique Grasselly
Centre Technique Interprofessionnel des Fruits et Légumes
30127 Bellegarde
FRANCE
Tel: 011-33-66-011054 Fax: 011-33-66-016228

Dr. Bruce Heming
Dept. of Entomology
University of Alberta
Edmonton, Alberta T6G 2E3
CANADA
Tel: 403-492-4652 Fax: 403-492-1767

Robert Jacobson
Horticulture Research International
Stockbridge House, Cawood, Selby
North Yorkshire, YO8 OT2
United Kingdom
Tel: 011-44-757-268275
Fax: 011-44-757-268996

Dr. Marshall W. Johnson
Entomology Department
Univ of HI of Manoa
Honolulu, HI
96822
Tel: 808-956-8432 Fax: 808-956-2428

Dr. William D.J. Kirk
Dept. of Biological Sciences
Keele University
Keele, Staffs ST5 5BG
UNITED KINGDOM
Tel: 011-44-782-621111 Fax: 011-44-782-630007

Dr. Peter Konjoian
Konjoian's Greenhouse
221 Chandler Rd.
Andover, MA 01810
Tel: 508-683-1114 Fax: 508-683-6962

Dr. Thomas F. Leigh
US Cotton Res. Sta.
17053 Shafter Ave.
Shafter, CA
93263
Tel: 805-746-6391 Fax: 805-746-1619

Professor Trevor Lewis
Rothamsted Expt. Station
AFRC Inst. of Arable Crops
Harpenden Herts AL5 2JQ
UNITED KINGDOM
Tel: 011-44-582-763133 Fax: 011-44-582-461366

Dr. Chris Mollema
Centrum voor Plantenveredelings
en Reproduktieonderzoek
Mansholtlaan 15 Postbus 16
6700 AA Wageningen
THE NETHERLANDS
Tel: 011-31-837-077285 Fax: 011-31-837-016513

Dr. Gerald Moritz
Martin-Luther Universität
Institut für Zoologie/Fachbereich Biologie
Domplatz 4
D-06108 Halle
GERMANY
Tel: 011-49-345-28182 Fax: 011-49-345-29515

Dr. Joseph G. Morse
Department of Entomology
Univ. of California
Riverside, CA
92521
Tel: 714-787-5814 Fax: 714-787-3086

Professor Laurence A. Mound
The Natural History Museum
Cromwell Rd.
London SW7 5BD
UNITED KINGDOM
Tel: 011-44-719-389124 Fax: 011-44-719-388937

Dr. Tamotsu Murai
Shimane Agricultural Experimental Station
2440 Ashiwata
Izumo, Shimane 693
JAPAN
Tel: 011-81-853-226650 Fax: 011-81-853-218380

Dr. Sueo Nakahara
Systematic Entomology Lab
USDA/ARS, Rm. 5, Bldg. 004
BARC-WEST
Beltsville, MD
20705
Tel: 301-344-3893 Fax: 301-504-6482

Dr. Michael Parrella
Department of Entomology
UCLA - Davis
Davis, CA
95616
Tel: 916-752-0492 Fax: 916-752-1537

Dr. P.M.J. Ramakers
Glasshouse Crops Research
Postbus 8
2670 AA Naaldwyk
THE NETHERLANDS
Tel: 011-31-174-036700 Fax: 011-31-174-036835

Dr. Karen Robb
Univ. of CA Coop. Ext.
5555 Overland Ave.
Bldg. 4
San Diego, CA
92123
Tel: 619-694-2857 Fax: 619-694-2849

Dr. Gerd Schreiter
Institut für Mikrobiologie
Fachbereich Biologie
Weinbergweg 16a
D-06108 Halle/S.
GERMANY
Tel: 011-49-345-617371 Fax: 011-49-345-617312

Dr. Anthony M. Shelton
NYS Agric. Expt. Sta.
Department of Entomology
Cornell Univ.
Geneva, NY
14456
Tel: 315-787-2352 Fax: 315-787-2326

Dr. J. Les Shipp
Agriculture Canada Research Sta.
Harrow, Ontario NOR 1GO
CANADA
Tel: 519-738-2251 Fax: 519-738-2929

Dr. Marilyn Steiner
Alberta Environmental Center
Bag 4000
Vegreville, Alberta TOB 4LO
CANADA
Tel: 403-632-8224 Fax: 403-632-8379

Dr. Sharon Strauss
Universitity of Illinois
Department of Entomology
320 Morrill Hall, 505 S. Goodwin Ave.
Urbana, Illinois
61801
Tel: 217-333-4971 Fax: 217-244-3499

Colleen Teerling
University of New Brunswick
Bag Service #44555
Fredericton, NB E3B 6C2
CANADA
Tel: 506-453-4501 Fax: 506-453-3538

Dr. Irene Terry
Biology Department
University of Utah
Salt Lake City, UT
84162
Tel: 801-581-5416 Fax: 801-

Dr. James W. Todd
P.O. Box 748
Coastal Plain Exp. Sta.
Tifton, GA
31793
Tel: 912-386-3374 Fax: 912-386-3086

Dr. Diane E. Ullman
University of Hawaii
Department of Entomology
3050 Maile Way
Honolulu, Hawaii
96822
Tel: 808-956-2452 Fax; 808-956-2428

Dr. Liliana Vasiliu-Oromulu
Academia Română
Institutul de Biologie
Splaiul Independentei 296
79651 București
ROMANIA
Tel: 011-40-0-6373390 Fax: 011-40-1-6372860

Dr. Gijsbertus Vierbergen
Plantenziektenkundige Dienst
Postbus 9102
6700 HC Wageningen
THE NETHERLANDS
Tel: 011-31-837-096324 Fax: 011-31-837-021701

Professor Richard zur Strassen
Forschungsinstitut Senckenberg
Anlage 25
D-60325 Frankfurt am Main
GERMANY
Tel: 011-49-69-7542252 Fax: 011-49-69-746238

APPENDIX IV:

LIST OF POSTER PRESENTATIONS
(NB: SUB-DIVIDED BY CONFERENCE ORGANISERS)

- Index of Poster Presentations -

Background Biology

03: Identification of *Frankliniella occidentalis.*
11: Establishing thrips cell cultures to study *Tospoviruses.*
13: Colour preference of *Frankliniella occidentalis.* (Pergande) (Thysanoptera: Thripidae).
14: Determination of the median latent period of two tospoviruses in *Frankliniella occidentalis* by using a novel leaf disc assay.
15: Multiplication of tomato spotted wilt virus in its insect vector, *Frankliniella occidentalis.*
20: Bioethology of *Frankliniella occidentalis* Pergande on table grapes in Apulia.
44: Activity and development of the pear thrips, *Taeniothrips inconsequens* (Uzel), in a Connecticut apple orchard.
50: Effect of anisaldehyde and a yellow color on behaviour and capture of western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae).
61: Egg laying sites of the thrips predator *Orius majusculus* in cucumbe crops.
64: Comparison of the life histories of *Frankliniella occidentalis* and *Thrips tabaci* (Thysanoptera: Thripidae) on cucumber.

Phytophagy and its Effects

29: The Californian thrips, *Frankliniella occidentalis* Pergande, and the TSWV in Crete.
39: Transmission of peanut bud necrosis virus by *Thrips palmi* in India.
40: Fixation techniques for observing thrips anatomy and injury to citru tissue with light, scanning and transmission electron microscopy.
42: Monitoring of *Frankliniella occidentalis* as a TSWV vector in tomato crops.
45: Pepper varietal responses to thrips feeding.
46: Thrips vectors responsible for the secondary spread of tomato spotted wilt tospovirus in south Texas peanut.
Histological study of tobacco thrips feeding on peanut foliage.
53: Influence of introduced basswood thrips-induced defoliation on subsequent foliar suitability.
55: Impact and economic threshold for onion thrips (*Thrips tabaci* Lindeman) on onions.

Population Biology and Ecology

02: Degree-day models for slash pine flower thrips and phenology of female strobili in slash pine seed orchards.
24: Possible dissemination of pest fungi by thrips.
30: Differential population density of the western flower thrips, *Frankliniella occidentalis* (Pergande) in various flower colours of gladiolus.
32: A Weibull function for phenology of pear thrips (*Taeniothrips inconsequens* (Uzel)) emergence in Pennsylvania sugar maple stands.
52: Position and abundance of *Taeniothrips inconsequens* (Uzel) eggs in flowering and vegetative buds of *Acer saccharum* Marsh.
56: Comparison of two sequential sampling procedures for onion thrips (*Thrips tabaci* Lindeman) on onions.
57: Modeling the thermal dependence of *Amblyseius cucumeris* and *Orius insidiosus*, two predators of greenhouse thrips.

Pest Distribution and Crop Infestations

04: Thrips fauna in North Carolina agroecosystems.
06: Enhancement of purple blotch disease of onion by thrips injury.
07: *Frankliniella occidentalis* in chrysanthemum.
08: Influence of flowers on the distribution of WFT on the plant.
16: Using a suction trap system to determine the range and in flight densities of the barley thrips *Limothrips denticornis* Haliday.
17: Distribution of *Frankliniella occidentalis* in Spain: Hosts, behaviors and implications.
18: Population trends in thrips infesting peppers.
22: Preliminary investigation of thrips, *Frankliniella fusca* (Hinds), spring movement into peanuts in North Carolina.
23: Pear thrips patterns of abundance in the northeastern United States, 1990-1992.
33: Overwintering and distribution of western flower thrips (Thysanoptera: Thripidae) in Pennsylvania.
34: Distribution and abundance of thrips in nectarine orchards in the Okanagan Valley, British Columbia, Canada.
36: The major pest thrips in Taiwan.
47: Broadleaf weed hosts harboring tobacco thrips, Frankliniella fusca (Thysanoptera: Thripidae), in central and south Texas.
49: Mobility of *Frankliniella* thrips within tomato plots.
51: The New Zealand flower thrips, *Thrips obscuratus* (Crawford) (Thysanoptera: Thripidae): A pest of stonefruit in New Zealand.
60: Thrips species and spotted wilt disease in a Mississippi peanut field: 1992.
65: Thrips of vegetables and other commercially important crops in Thailand.

Biological Control

05: The global role of the USDA-ARS collection of entomopathogenic fungal cultures in thrips biocontrol.

12: Manipulation of the predatory mite, *Euseius tularensis*, for improved control of citrus thrips, *Scirtothrips citri*.

13A: Biological control of *Frankliniella occidentalis* with *Orius laevigatus* i: organic strawberries in Portugal.

21: Biological control of the onion thrips on tobacco seedings in Ukraine

26: Biological control of thrips pests. Evaluation of *Ceranisus menes* (Hymenoptera: Eulophidae) as a control agent of *Frankliniella occidentalis* (Thysanoptera: Thripidae): Biology and behavior.

28: Control of western flower thrips on sweetpepper during winter by use of *Amblyseius cucumeris* and *A. degernerans* (Acari: Phytoseiidae).

31: 'KEEP DOWN' - The concept of biological thrips control in ornamental pot plants.

37: The predatory ability of *Campylomma chinensis* Schuh (Hemiptera: Miridae) and *Orius sauteri* (Poppius) (Hemiptera: Anthocoridae) on *Thrips palmi* Karny.

41: Native predators of *Frankliniella occidentalis* in horticultural crops.

62: IPM implementation in New York greenhouses.

63: Preselection of predatory mites for the control of western flower thrips (*Frankliniella occidentalis*), in greenhouse crops during winter.

Integrated Pest Management

10: Cultural management of greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), in coastal California Hass avocados using an early harvest strategy.

27: Thrips (*Frankliniella occidentalis* (Pergande)) resistance in chrysanthemum.

35: Thrips resistance in gladiolus species: Potential for IPM and breeding.

38: Insecticide resistance in western flower thrips, *Frankliniella occidentalis* (Pergande).

43: A survey of the susceptibility of UK populations of western flower thrips to the pesticides dichlorvos and malathion.

58: Effect of postharvest Naled and Sulfotep fumigation on western flower thrips infesting carnation.

59: Sustainable management of cowpea thrips in Africa.

APPENDIX V:

ABSTRACTS OF POSTER PRESENTATIONS OF
INTEREST TO UK GROWERS

(NB: SUB-DIVIDED BY CONFERENCE ORGANISERS)

Background biology.

13A

Biological control of *Frankliniella occidentalis* with *Orius laevigatus* in organic strawberries in Portugal.

C. Frescata & A. Mexia

Presented by: Célia Mateus
Secção Autónoma de Protecção Integrada
Insitituto Superior de Agronomia
Tapada da Ajuda
1399 Lisboa Codex, Portugal

The results of a field trial done in the Algarve, Southern Portugal, ar presented and discussed to assess the efficacy of *Orius laevigatus* (Fiebe [Heteroptera: Anthocoridae] as a biocontrol agent to fight *Frankliniell occidentalis* (Pergande) [Thysanoptera: Thripidae] on organic farmin strawberries in greenhouses. The role of the pollen from Compositae wee as an alternative food source in either the presence of absence of the crop as well as its use in a rearing open unit, is discussed.

50

Effect of anisaldehyde and a yellow color on behaviour and capture of western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae).

E.A. Cameron, D.A.J. Teulon & B. Hollister

Presented by: E. Alan Cameron
The Pennsylvania State University
Department of Entomology
501 ASI Bldg.
University Park, PA 16802

Observations in a flight chamber olfactometer and in glasshouses planted either to sweet pepper or tomato suggest a chemokinetic response by western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), to p-anisaldehyde rather than a response based on anemotaxis, chemotaxis, or an odor-induced visual response. Yellow water traps, baited with p-anisaldehyde, increased capture of WFT by more than 10-fold over non-baited yellow traps, and by over 100-fold over non-baited black traps. Evidence of baited trap interference with nearby non-baited traps was detected, suggesting a need for caution in interpretation of baited vs. non-baited trap catches under glasshouse conditions where traps are not adequately spaced.

61

Egg laying sites of the thrips predator *Orius majusculus* on cucumber crops.

R.J. Jacobson

Presented by: Robert J. Jacobson
HRI, Stockbridge House
Cawood, Selby, North Yorkshire YO8 0T2, United Kingdom

Effective control of *Frankliniella occidentalis* (Pergande) has been achieved with the predator, *Orius majusculus* (Reuter) (Heteroptera: Anthocoridae), in pepper crops but results have been disappointing in cucumbers.

O. majusculus oviposition sites were located on cucumber plants by confining adult insects with plant material in perspex containers and by direct observations in a commercial crop. The most common sites were found to be the leaf veins, leaf petioles, leaf axils and flower sepals of the youngest 500 mm of growth. Eggs were usually lad individually, or in groups of 2 to 3, but in restricted space there were clusters of up to 10. No eggs were found in the actual growing points which are densely hairy.

During routine crop work unwanted lateral shoots are removed which could, on average, result in the loss of 30% of unhatched eggs. Furthermore, some eggs laid in the short lived flowers may not complete their development.

These observations help to explain why establishment of *O. majusculus* in cucumber crops is slower than expected in late spring and early summer although other factors must be involved.

Phytophagy and its effects.

41

Native predators of *Frankliniella occidentalis* in horticultural crops.

J. Riudavets, C. Castañé & R. Gabarra

Presented by: Jordi Riudavets
IRTA
Centre de Cabrils
Carreterra de Cabrils
08348 Cabrils (Barcelona), Spain

A survey of the *Orius* (Hem. Anthocoridae) species composition was done in several ornamental and vegetable crops along the North East spanish coast. *O. laevigatus* and *O. majusculus* are the more common species. Other species present are : *O. albidipennis, O. laticollis* and *O. niger*.

During 1991 and 1992 cucumber, tomato, bean, pepper, strawberry and carnation plants were sampled in experimental plots for native predators of *F. occidentalis*. *O. majusculus* and *O. laevigatus* were abundant on peppers, beans and cucumbers and scarce on tomatoes and carnations. Predatory mirid bugs (*Dicyphus tamaninii* and *Macrolophus caliginosus*) were abundant on tomatoes and cucumbers, scarce on strawberries and beans, and absent on carnations and peppers.

All four species are able to complete their nymphal development, lay eggs and survive as adults more than one month when fed exclusively on *F. occidentalis* at 25°C.

29

The Californian thrips, *Frankliniella occidentalis* (Pergande), and the TSWV in Crete.

N.E. Roditakis, A. Avgelis & D. Likouressis

Presented by: Nikos Roditakis
Plant Protection Institute
P.O. Box 1802
71110 Heraclion, Crete, Greece

The Californian thrips, *Frankliniella occidentalis* (Pergande), was first noticed on greenhouse sweetpeppers in the Ierapetra area (southern Crete) in the 1987-1988 crop season. It spread rapidly during the next years injuring severely greenhouse crops and flowers (cucumbers, melons, beans, eggplants, strawberries, carnations, zerberas and roses) and moderately open air crops (beans, eggplants, cucumbers, melons and table grapes neighboring the greenhouses).

Tomato spotted wilt virus II (TSWV) was first noticed on greenhouse sweetpeppers in the Ierapetra area in 1991-1992 causing severe crop losses. The virus was identified on the basis of its biological, morphological and serological features as an isolate of the lettuce strain of TSWV.

The registered insecticides for greenhouse crops were ineffective. Among the other insecticides tested, methiocarb 50% WP (Mesurol) was the most effective (97. 4%). Among the biological agents used, an indigenous predator *Orius* sp was the most perspective. A mass trapping method based on 50 blue shade plastic sheet traps/1000 m^2 (total plastic surface 16 m^2) gave satisfactory control in combination with registered insecticides.

Experiments carried out on chromotropism of thrips showed that a shade of blue, the white and the fuschia color were the most attractive. The blue trap catches were 5-80 fold greater on those hung at a 30 cm height over the ground than those hung at 70 and 200 cm, until the plants were fully grown.

45

Pepper varietal responses to thrips feeding.

G. Nuessly & R. Nagata

Presented by: Gregg Nuessly
University of Florida
IFAS
Everglades Research & Education Center
Belle Glade, FL 33430

Pepper foliage, flower, and fruit feeding by *Thrips palmi* and *Frankliniella occidentalis* caused >$10 million damage to south Florida peppers during the 1992-93 season. Field and greenhouse trials with natural and caged thrips populations, respectively, were conducted to evaluate the relative sensitivity to thrips feeding among the common pepper types grown in Palm Beach Co. Sweet and jalapeno types were more sensitive to both foliar and fruit damage than cayenne and cubanelle types. Fruit scarring was caused by feeding on the fruit and calyx. Fruit distortion resulted when pollination, and thereby seed set, were reduced due to feeding damage to the style and stigmatic surfaces.

42

Monitoring of *Frankliniella occidentalis* as a TSWV vector in tomato crops.

J. Arnó, J. Riudavets, E. Moriones, J. Aramburu, A. Laviña & R. Gabarra

Presented by: Jordi Riudavets
IRTA
Centre de Cabrils
Carreterra de Cabrils
08348 Cabrils (Barcelona), Spain

Tomato Spotted Wilt Virus (TSWV) is an important problem in tomato and other horticultural crops since the outbreak of *Frankliniella occidentalis* in Spain.

A suitable monitoring method that relate adult thrips populations to TSWV epidemiology in open field tomatoes is studied. Fields with a previous history of high and low TSWV incidence are chosen, being some of them under an Integrated Pest Management (IPM) program. Predatory bugs and thrips are counted in: 1) 10 leaflets per plant; 2) 1 flower cluster per plant; 3) blue sticky traps; 4) transparent sticky traps. Percentage of plants with symptoms of the virus are recorded.

Adult thrips are more abundant in flower clusters than in leaflets, and predators are also detected in the flowers. In additions, sampling flowers is less time consuming and easier to apply than sampling leaflets; so, in 1993 flowers are sampled to estimate thrips and predator populations. Blue and transparent sticky traps show the same pattern of thrips catches. Both seem to be a good indicator of immigrating thrips. Since now, catches in traps cannot be related with the thrips recorded on plant.

More data need to be obtained to assess the goodness of each method to explain TSWV incidence.

Population biology and ecology.

24

Possible dissemination of pest fungi by thrips.

R. Marullo

Presented by: Rita Marullo
Instituto di Entomologia Agraria e Forestale
Via Nazario Sauro 85
85-100 Potenza, Italy

The Thysanoptera fauna in leaf litter was studied in an area of forestry and mixed cereals, in the mountain community of Lagonegro (Basilicata, Potenza Province, Italy), Living conidia of *Fusarium moniliforme*, a fungus causing parenchymal necrosis in wild and cultivated Graminae, were extracted from the gut of *Hoplothrips pedicularius* (Haliday) on *Quercus* and *Fagus sylvatica* litter. A survey of *Chirothrips manicatus* Haliday, *Limothrips denticornis* Haliday and *Stenothrips graminum* Uzel on cereals during spring and summer also demonstrated the presence of living spores and conidia in the gut of the adult thrips. these were extracted and reared in Petri dishes on PDA, and colonies of *Cladosporium herbarum*, *Aspergillus flavus* and *Penicillium* spp. were obtained. Laboratory experiments are continuing to determine how thrips are able to carry live spores internally.

30

Differential population density of the western flower thrips, *Frankliniella occidentalis* (Pergande) in various flower colours of gladiolus.

R. Chyzik, M. Klein, Y. Ben-Dov,& A. Coben

Presented by: Yair Ben-Dov
Department of Entomology
Agricultural Research Institute
50 250 Bet Dagan, Israel

Adult populations of the Western Flower Thrips, *Frankliniella occidentalis* (Pergande) were sampled on nine hybrids of *Gladiolus grandiflorus* (Calvelli), in Israel, for two years (1992, 1993) in May and June. The sampled hybrids were:

Parents		Hybrids' colour
Fidelio (dark violet)	X Day Dream (lilac)	pink
Fidelio (dark violet)	X Day Dream (lilac)	white
Judith (dark red)	X Selle Etiole (yellow)	dark pink
Eurovision (red-orange)	X Kings' Ransom (dark red)	dark red
Eurovision (red-orange)	X Kings' Ransom (dark red)	orange
Oscar	X Jacksonville Gold	yellow
Centurio op. (violet)		violet
Country Girl		lilac
		red

The population in the lilac and violet hybrids were significantly higher than on all other colours. The lowest populations were recorded on red and orange hybrids. The number of thrips significantly differed between samples taken in the morning, noon and evening. The sex ratio changed in favour of males, with aging of the flower in all colours.

57

Modeling the thermal dependence of *Amblyseius cucumeris* and *Orius insidiosus*, two predators of greenhouse thrips.

C. Cloutier, D. Arodokoun, S.G. Johnson & L. Gélinas.

Presented by: Conrad Cloutier
Department of Biology
Laval University
Ste-Foy, Quebec G1K 7P4, Canada

Characterizing the thermal dependence of development and reproduction is important to predict the performance of natural enemies used in biological control. We studied development and reproduction of commercially obtained *Amblyseius cucumeris* (Oudemans) (Acarina: Phytoseiidae) and *Orius insidiosus* Say (Hemiptera: Anthocoridae) reared on western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), prey on English cucumber foliage at several constant temperatures within the range of normal variation observable in a modern greenhouse facility. The data were used to estimate the parameters of regression models describing the rates of development and population increase as nonlinear functions of temperature, under conditions of unlimited prey availability. An independent test was conducted to verify model predictions of the thermal responses of *A. cucumeris*, under two regimes of daily temperature fluctuation following a sine wave pattern with an 8°C amplitude. The validity of the models was found to be adequate, with an error rate of only about 10%.

07

Frankliniella occidentalis in chrysanthemum.

F.R. van Dijken, C. Mollema & J. de Jong

Presented by: Folchert R. van Dijken
Centre for Plant Breeding and Reproduction Research
Mansholtlaan 15
6708 PA Wageningen, The Netherlands

Effects of thrips on green leaves of chrysanthemum in non-flowering plants and in flowering plants have been studied. The development of the thrips population on flowers of different gene types is different. Flower colors play no role at all in a no-choice situation either on the development of damage or on the population growth of the thrips.

08

Influence of flowers on the distribution of WFT on the plant.

C. Gerin

Presented by: Celile Gerin
Université Catholiqué de Louvain
Unité d'ecologie et de biogéographie
Place Croix du Sud, 5
B-1348 Louvain-La Neuve, Belgium

In order to study the influence of the flowers on the spatial distribution of the thrips within the plant, three complementary experiments were done;

1) Impact of flowers on thrips demography: the growth of thrips population on french bean and sweet pepper plants is analyzed in presence or absence of the flowers.

2) Daily distribution of the thrips: thirty-six french bean and sweet pepper plants are used (3 replications). All the plants are infested in the same way. After 10 days, three plants are sampled every two hours and the localization of the thrips is recorded.

3) Use of olfactometry to study the attractivity of the flowers on the different stages of the thrips, taking into account plant species and varieties.

18

Population trends in thrips infesting peppers.

G. Frantz

Presented by: Galen Frantz
Glades Crop Care, Inc.
949 Turner Quay
Jupiter, FL 33458

The seasonal distribution of Florida flower thrips *Frankliniella bispinosa* (Morgan), western flower thrips, *Frankliniella occidentalis* (Pergande) and melon thrips, *Thrips palmi*, Karny, was determined by examining samples of pepper blooms from 1991 to 1993. Population peaks are influenced by cultural practices on individual farms, and reach economically damaging levels earlier in the most intensively cropped fields.

33

Overwintering and distribution of western flower thrips (Thysanoptera: Thripidae) in Pennsylvania

C.M. Felland, D.A.J. Teulon & L.A. Hull

Presented by: Carl M. Felland
The Pennsylvania State University
Fruit Research Laboratory
Biglerville, PA 17307

Western flower thrips (*Frankliniella occidentalis* (Pergande)) caused extensive injury to stone fruit in south central Pennsylvania in 1991. During 1992 and 1993 the overwintering emergence of this species in a nectarine orchard and the distribution of this species in the Commonwealth were monitorea. Western flower thrips adults were recovered from emergence traps in spring 1992 following high densities the previous fall but were not recovered from traps in the same orchard in 1993 following lower densities in fall 1992. However, western flower thrips were numerous in nearby sites in spring 1993, suggesting that this species continues to overwinter. Western flower thrips was determined to be the dominate thrips species in white clover flowerheads in some areas of southern Pennsylvania in the summers of 1992 and 1993.

34

Distribution and abundance of thrips in nectarine orchards in the Okanagan Valley, British Columbia, Canada.

I.A. Pearsall & J.H. Myers

Presented by: Isobel Pearsall
University of British Columbia
Department of Plant Science
Vancouver, BC V6T 1Z4, Canada

Thrips were sampled from four nectarine orchards between April and June 1993 using yellow sticky cards placed on 2 m high posts spaced at 30°intervals around the perimeter of each orchard. Densities of each species of thrips and direction of their movement into and out of the orchard were monitored in relation to wind direction, surrounding vegetation, temperature, precipitation, and the stage of development of the nectaring buds. Vertical variation in thrips movement was assessed using cards placed at heights of 0.25, 1 1.5 and 2 m and correlated with tree height and the type of ground cover in each orchard.

A comparison is made between two orchards situated close to large tracts of wild land and two orchards located lower in the valley, away from large source areas of thrips.

49

Mobility of *Frankliniella* thrips within tomato plots.

H. Puche & J. Funderburk

Presented by: Helena Puche
152 Tier St. #112C
City Island, NY 10464

To explore the potential role of *Frankliniella* thrips movement in the spread of the spotted wilt of tomatoes (TSWV), we measured changes in the spatial gradients of thrips densities over time, under greenhouse conditions. Movement behavior of *Frankliniella* thrips was quantified by mark-recapture experiments. Recapture distributions of marked thrips were analyzed using a passive diffusion model and a continuous-time Markov model. Dispersal rates and coefficients of diffusion of *Frankliniella* thrips decreased with time and distance. In some instances, higher densities of thrips were found at experimental traps (tomato flowers) located at larger distances. Furthermore, the dispersal rates were density dependent. Since movement is the mechanism by which thrips respond to environmental heterogeneity, rates and patterns of thrips movement determine their ability to concentrate on the best food plants.

The methodology used in these experiments is crucial to initiate more ecological studies on the influence of *Frankliniella* thrips movement on the spread of TSWV. This information has important implications for modeling thrips movement and dispersal. When combined with a population dynamics submodel, predictions can be made on the likely spread of thrips, the resulting economic consequences of thrips invasion, and transmission of the spotted wilt of tomatoes. The final model can be useful in determining optimal strategies for the control of thrips and the tomato spotted wilt virus in tomato fields.

Biological control.

13

Colour preference of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae).

C. Mateus & A. Mexia

Presented by: Célia Mateus
Secção Autónoma de Protecção Integrada
Insitituto Superior de Agronomia
Tapada da Ajuda
1399 Lisboa Codex, Portugal

Greenhouse trials (plastic houses with ornamentals and strawberries) we done to study the preference of *Frankliniella occidentalis* (Pergand (Thysanoptera, Thripidae) to different colours, in order to develop adequa traps for its monitoring and control. Nine coloured sticky traps were teste three white shades, three yellow and three blue ones. Two blue shades bright and a dark shade) were the most attractive ones for this specie These two traps were tested against the Horiver-Tr trap (from Koppert B.V which captured more individuals than the other two (but without significa differences in relation to the dark blue one). The bright yellow shad widely used in insect's monitoring, didn't perform better than some of t other colours/shades and trapped a higher number of beneficials. Tra hung up immediately above the top of the crop caught more individuals th those in higher positions.

26

Biological control of thrips pests. Evaluation of *Ceranisus menes* (Hymenoptera: Eulophidae) as a control agent of *Frankliniella occidentalis* (Thysanoptera: Thripidae): Biology and behavior.

A.J.M. Loomans, T. Murai, J.P.N.F. van Heest & J.C. van Lenteren

Presented by: Antoon J.M. Loomans
Wageningen Agricultural University
Postbus 8031
6700 EH Wageningen, The Netherlands

The potential of *Ceranisus menes* (Walker) (Hymenoptera: Eulophidae), a solitary endoparasitoid of thrips larvae, was evaluated in laboratory experiments as a control agent against the Western Flower Thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), using both direct observation (behaviour) and indirect experimental set-ups (biology). A method is described for rearing thrips and parasitoids, using bean pods as host plant material and different *Frankliniella* species (*occidentalis and schültzei*) as hosts. Strains collected worldwide, differed in biology and behaviour, according to their phenotypic appearance (abdomen colour-types: yellow versus brown) and geographical origin. Yellow types showed a higher reproduction than brown types, but showed a large variation in developmental time, whereas brown types did not. Detailed analysis of host acceptance behaviour showed that with increasing size of the host larvae, significantly less larvae were attacked and parasitized. For both colour-types, attack time increased with size, and insertion ratio decreased, yellow strains performing better than brown strains.

28

Control of western flower thrips on sweetpepper during winter by use of *Amblyseius cucumeris* and *A. degernerans* (Acari: Phytoseiidae)

Y.M. van Houten

Presented by: Yvonne M. van Houten
Proefstation voor Tuinbouw onder Glas
Postbus 8
2670 Naaldwijk, The Netherlands

In the present study a non-diapausing strain of *A. cucumeris* and a drought-resistant non-diapausing strain of *A. degenerans* are compared with respect to their establishment and efficacy in controlling Western Flower Thrips in a sweet pepper crop during the period of January to April. Both predators were released in separated greenhouses on a crop infested with thrips.

The results showed that both *A. cucumeris* and *A. degenerans* were successful in establishment during the winter period. The impact on thrips populations was much greater for *A. degenerans* than for *A. cucumeris*.

31

'KEEP DOWN' - The concept of biological thrips control in ornamental pot plants.

H.F. Brødsgaard

Presented by: Henrik F. Brødsgaard
Statens Planteavlsforsøg
Planteværnscentret
Lottenborgvey 2
2800 Lyngby, Denmark

Ornamentals are sold for their aesthetic value and, thus, very little cosmetic damage is tolerated on top quality plants. Compared to cut flowers, the situation in potted ornamentals is even more delicate as whole plants are sold (leaf damage as well as flower damage is not tolerated) and the production time is very short for most cultures. This means that, only rarely is it a real possibility to save crops from damaging thrips attacks by means of curative 'knock-down' introductions of beneficials.

Introduction of biological thrips control is nearly always doomed to fail if the grower's only incentive is that the pesticides that are available are not effective anymore (due to resistance, spray damage, legislation, or working environmental problems). In this case the grower will most surely be using the biologicals as he is using chemicals. In such cases the. damage thresholds are very likely to be crossed before successful control is obtained due to the inertia of the biological system. It is, therefore, of crucial importance for the success of biological thrips control in greenhouses that the individual grower snap out of the traditional way of dealing with pests; e.g., pests are not dealt with at all, unless the populations have reached the economic damage thresholds. Only then are applications of pesticides initiated.

The 'keep-down' strategy of biological pest control in ornamental pot plants is 1) identification of the key pests based on earlier experience 2) prophylactic introductions of selected beneficials 3) regular monitoring/scouting of the crop. The aim of this strategy is to never letting the pest populations get near to the damage thresholds by means of 'over-kill' introductions of beneficials without a resulting thrips-beneficial-balance as is aimed in vegetable crops. Furthermore, if introductions of beneficials are started on the very young plants, the pest numbers are usually small and the leaf area to be effectively searched by the beneficials is small, too, (compared to later stages in the crop production cycle). Therefore,correspondingly few beneficials are necessary for controlling the thrips. Thus, prophylactic treatments of potted ornamental crops are often cheaper than curative treatments later in the plant production phase.

63

Preselection of predatory mites for the control of western flower thrips (*Frankliniella occidentalis*), in greenhouse crops during winter.

P.C.J. van Rijn, Y.M. van Houten, L.K. Tanigoshi & P.van Stratum

Presented by: Paul C.J. van Rijn
University of Amersterdam
Department of Pure & Applied Ecology
Kruislaan 302
1098 SM Amsterdam, The Netherlands

Two groups of natural enemies are successfully used for biological control of *Frankliniella occidentalis* in greenhouses: phytoseiid mites (*Amblyseius cucumeris* and *A. barkeri*) and anthocorid bugs (*Orius* spp.). During winter, however, these predators often fail to control the pest. The tendency of these predators to enter diapause under short day conditions, is likely to be one of the reasons. In addition, eggs of the predatory mites are susceptible for low humidity conditions, which often arise when outside temperatures drop below zero. In search for a predator that is not hampered by these conditions, five subtropical phytoseiid species were selected, which were known to feed on thrips: *A. hibisci, A. degenerans, A. limonicus, A. scutalis* and *A. tularensis*. These species were compared with *A. cucumeris* and *A. barkeri*, with respect to the following features:

1) predation and oviposition rate with young larvae of F. occidentalis as prey,
2) oviposition rate on a diet os sweet pepper pollen,
3) humidity tolerance spectrum of eggs, and
4) incidence of reproductive diapause under short day condition.

The results showed that *A. degenerans* and *A. hibisci* are good candidates for biological control of *F. occidentalis* under conditions of low humidity and short day length.

Integrated pest management.

43

A survey of the susceptibility of UK populations of western flower thrips to the pesticides dichlorvos and malathion.

O. Macdonald

Presented by: Keith Walters
Central Science Laboratory
Hatching Green
Harpenden, Herts AL5 2BD, United Kingdom

Samples of *Frankliniella occidentalis* from major horticultural areas around the UK were tested using a simple bioassay for their response to the pesticides malathion and dichlorvos. A maximum of three fold differences in susceptibility to malathion were found between populations, but more than 20 fold differences were found in the response of populations to dichlorvos. The population with the highest tolerance to dichlorvos came from a site that not been treated with that pesticide, however the origin of the insects infesting the site was unknown. The population that was most susceptible to dichlorvos came from a glasshouse trial where the insects had been released from a laboratory culture that had been free of any insecticide pressure for at least two years. An adjacent experimental area, infested with insects from the same source but which had been sprayed three times with dichlorvos, showed and increase in tolerance of more than ten times at the LD_{60} level. Overall, no relationship between levels of tolerance and control failures in commercial crops was found. However, the heterogeneity in the responses to dichlorvos and the sharp increases in tolerance in newly treated populations suggest that *F. occidentalis* may have the potential to develop higher levels of resistance.

27

Thrips (*Frankliniella occidentalis* (Pergande)) resistance in chrysanthemum.

C.M. de Jager & R.P.T. Butôt

Presented by: C. M. de Jager
University of Leiden
Postbus 9516
2300 RA Leiden, The Netherlands

The use of pesticides against pests in agriculture is a threat to the environment. Thrips resistant chrysanthemum cultivars can be used in order to reduce the pressure on the environment. As breeding for insect resistance is very time consuming, the aim of this project is to develop a rapid biotechnological test for chrysanthemum seedlings on insect resistance. To develop such a test it is important to have knowledge about the mechanisms behind thrips resistance in chrysanthemum.

Firstly the genetic variation in chrysanthemum for resistance to *F. occidentalis* is investigated. In a choice experiment *F. occidentalis* resistance of 43 chrysanthemum cultivars was measured. Resistance was log-normal distributed, only a small number of cultivars were extremely susceptible. There is a great potential to select for *F. occidentalis* resistant cultivars.

Secondly it is important to know if the resistance found, is thrips species specific. Therefore the correlation between Chrysanthemum resistance to *F. occidentalis* and to *T. tabaci* is investigated. Resistance of 10Y different Chrysanthemum cultivars to both thrips species was measured. Chrysanthemum resistance to *F. occidentalis* was positively correlated ($R = 0.719$, $p = 0.019$) with resistance to *T. tabaci*.

At this moment we are investigating the modality (antibiosis, antixenosis) of thrips resistance in chrysanthemum. Every step gives us this way more insight in the mechanisms behind thrips resistance in chrysanthemum.

APPENDIX VI:

ABSTRACTS OF RELEVANT PAPERS AVAILABLE AT THE TIME OF PREPARATION OF THIS REPORT

Genotypic Effects of Cucumber Responses to Infestation by WFT.

CHRIS MOLLEMA, GREET STEENHUIS AND HEIN INGGAMER

DLO-Centre for Plant Breeding and Reproduction Research (CPRO-DLO). P.O.-Box, NL-6700 AA Wageningen, The Netherlands.

ABSTRACT

To study host plant resistance to Western Flower Thrips (*Frankliniella occidentalis* Pergande) methods for mass-rearing and for production of synchronized stages were developed. To quantify the damage caused by WFT, an automatic technique was developed using computer-aided image-analysis. A screening of a cucumber (*Cucumis sativus* L.) collection revealed several sources with intermediate to low levels of damage after standard infestation with Western Flower Thrips (WFT). Both young and mature plant stages showed significantly reduced levels of damage (> 60 % less damage than the susceptible control). A study of the effects of the genotypes with lower damage levels upon the reproductive fitness of WFT demonstrated reduced survival of immature stages, reduced reproduction of females, while the adult survival was not immediately affected. It is concluded that the reduced levels of damage are caused by resistance and not tolerance, and that the resistance does not cause an acute intoxication of WFT.

Key words: *Frankliniella occidentalis*, cucumber, genotypic resistance, reproductive fitness

Biological Control using Oligophagous Predators

P.M.J. RAMAKERS
Research Institute for Plant Protection, seconded to: Glasshouse Crops Research Station, P.O.Box 8, 2670 AA Naaldwijk, the Netherlands

ABSTRACT Spraying suspensions of bee-collected pollens on cucumber plants facilitated the establishment of the predatory mite *Amblyseius degenerans* Berlese (Acari: Phytoseiidae), and allowed it to reproduce in the absence of thrips or any other host. Repeated (3x) full crop applications with dosages of 80 and 8 kg/ha produced a predator density respectively 29 and 12 times higher than in control plots, but 0.8 kg/ha had no effect. Isolated predator colonies lasting for about a month could be created using 20 adult females and 0.5 gram of pollen per colony.

Feeding Behavior and Nutritional Requirements

WILLIAM D. J. KIRK

Department of Biological Sciences, Keele University, Keele, Staffordshire ST5 5BG, U.K.

ABSTRACT Thrips that live on plants can feed on a wide range of types of food. These foods are surveyed. Very little is known about the relative amounts of each food type that a thrips consumes in the field. Thrips may feed more opportunistically and have wider diets, in terms of food type, than has been recognised. It is proposed that many leaf-feeding thrips may also feed on pollen and be occasional predators. The high proportion of leaf-feeding species with wind-pollinated host-plants may reflect the nutritional advantage of being able to feed additionally on pollen that lands on the leaves.

DO GREENHOUSE GROWERS HAVE RESOURCES TO IMPLEMENT BIOLOGICAL CONTROL PROPERLY?

R JACOBSON

Horticulture Research International

Stockbridge House, Cawood, Selby, England, YO8 0TZ

ABSTRACT

The pest control strategies available to growers, and the factors which influence their choice, are examined to determine whether low pesticide input systems offer a realistic option in commercial horticulture. It is concluded that biological control programmes alone are rarely acceptable in glasshouse crops due to their complex management and the consequences of failure. However, integrated pest management (IPM) based largely on biological techniques with only minimal use of selective pesticides is an attractive option. Future developments, which could accelerate the acceptance of IPM, are discussed.

Thrips Transmission of *Tospoviruses*: Future Possibilities for Management

DIANE E. ULLMAN, THOMAS L. GERMAN, JOHN L. SHERWOOD, and DAPHNE M. WESTCOT.

First and fourth authors, Department of Entomology, University of Hawaii, 3050 Maile Way Rm 310, Honolulu, HI 96822.

ABSTRACT

Tomato spotted wilt tospovirus (TSWV) is the type member of the *Tospovirus* genus in the family Bunyaviridae. The *Tospoviruses* are the only plant infecting members of this large family of animal viruses, many of which cause serious diseases of humans and domestic animals. The *Tospoviruses* are transmitted by at least 8 species of thrips (Thysanoptera: Thripidae) and cause serious epidemics in many food, fiber and ornamental crops around the world. The thrips vectors and the viruses making up the *Tospoviruses* have large, overlapping host ranges that make management of virus spread one of the greatest challenges facing agricultural and ornamental industries today. The relationship between TSWV and its vectors, among which *Frankliniella occidentalis*, the western flower thrips, is thought to be most important, has only recently begun to be investigated. Molecular and serological investigation of thrips cells is elucidating mechanisms governing virus entry to cells, the role of TSWV membrane glycoproteins in thrips acquisition, the processes of TSWV replication within thrips cells and virus movement from cell to cell.

Mycopathogens for Thrips Management: Myth or Reality?

MICHAEL BROWNBRIDGE

University of Vermont, Entomology Research Laboratory, 655B Spear Street, South Burlington, Vermont 05446, USA.

2

ABSTRACT. With the need to reduce our reliance on chemical pesticides, there has been increasing interest in the exploitation of biological control agents for use in integrated pest management strategies. Of the biocontrol options considered for thrips, entomopathogenic fungi are particularly attractive candidates. The incidence of entomogenous fungi in thrips populations, and the efficacy of certain species against thrips in laboratory and greenhouse trials is documented. These data indicate the great potential Hyphomycete fungi have for use as mycoinsecticides in thrips supression programs but highlight the lack of experimental work specifically directed toward their use in such control approaches. A series of steps are suggested relevant to the development of fungal agents for thrips management, and are addressed in light of investigations on thrips and other insect pests, and recent advances in fungal technologies. Future research requirements include a need to develop a better understanding of the complex interrelationships between the pest, pathogen and the environment. The role molecular biology can play in the advancement of mycopathogens as practical control agents is briefly discussed.

Key words: thrips, fungi, entomopathogens, biological control, integrated pest management.

Chemical Ecology of Western Flower Thrips (Thysanoptera: Thripidae)

C. R. TEERLING

Department of Forest Resources, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 6C2.

ABSTRACT

The western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is a pest of field, orchard, and greenhouse crops. Western flower thrips nymphs were shown to produce an alarm pheromone. All mobile stages of thrips responded to the pheromone by walking away from the source. Other responses included dropping from leaves by nymphs, and reduced oviposition by adult females. Since second instars often produce a droplet of anal fluid which deters predators, and the alarm pheromone was found in this fluid, it was hypothesized that the alarm pheromone acts as a defensive allomone. This hypothesis was refuted by the demonstration that predators use the pheromone as a prey-finding kairomone. On a leaf arena, *Orius tristicolor* (Hemiptera: Anthocoridae) increased its rate of turning in response to the pheromone, and spent 25% of its time within 5 mm of the pheromone source. When given a choice between leaf discs containing a pheromone source or solvent, *Amblyseius cucumeris* (Acarina: Phytoseiidae) spent a greater proportion of time on the pheromone-containing disc, suggesting an arrestment effect. Because the response of western flower thrips to the alarm pheromone is so weak, the potential for its use in pest management is limited, unless it is used in conjunction with other control measures. Since it acts as a kairomone for predators, the alarm pheromone could possibly be used to enhance biological control in greenhouse crops.

Key Words - *Frankliniella occidentalis*, alarm pheromone, kairomone, Thripidae

The host-parasite interaction between *Frankliniella intonasa*, *Frankliniella occidentalis*(Thysanoptera:Thripidae) and *Ceranisus menes*(Hymenoptera:Eulophidae):development and reproduction.

TAMOTSU MURAI[1] AND ANTOON J.M.LOOMANS[2]

ABSTRACT

The life history of the solitary endoparasitoid of thrips, *Ceranisus menes* (Hymenoptera:Eulophidae) was studied in the laboratory on two different *Frankliniella* species: *Frankliniella intonsa* (Trybom) and *Frankliniella occidentalis* (Pergande). Both development of the parasitoid and reproductive capacity depended on temperature. Development is synchronized with larval development of the host species, development time being faster on *F.occidentalis* than those on other thrips species. There is a marked variation in pupal duration of *C.menes* at both temperatures. Average longevity of *C.menes* did not differ between *F.occidentalis* and *F.intonsa* at 25 °C. Fecundiy, however, was 2.5 times as high with *F.occidentalis* as hosts than with *F.occidentalis*. The intrinsic rate of increase(r_m) of *C.menes* on *F.occidentalis* was higher than that on *F.intonsa* at both temperatures, but was lower than those of the thrips hosts. Because of this, it is suggested that multiple releasing will be needed to control the *F.intonsa or F.occidentalis* pest outbreaks.

[1]Shimane Agricultural Experiment Station, 2440 Ashiwata, Izumo Shimane 693 Japan

[2]Department of Entomology, Agricultural University, P.O.Box 8031,6700 EH Wageningen, The Netherlands