AUSTRALIAN ENTOMOLOGICAL SOCIETY

26TH AGM AND SCIENTIFIC CONFERENCE PROGRAM and ABSTRACTS

FARRER MEMORIAL AGRICULTURAL HIGH SCHOOL
TAMWORTH, NSW

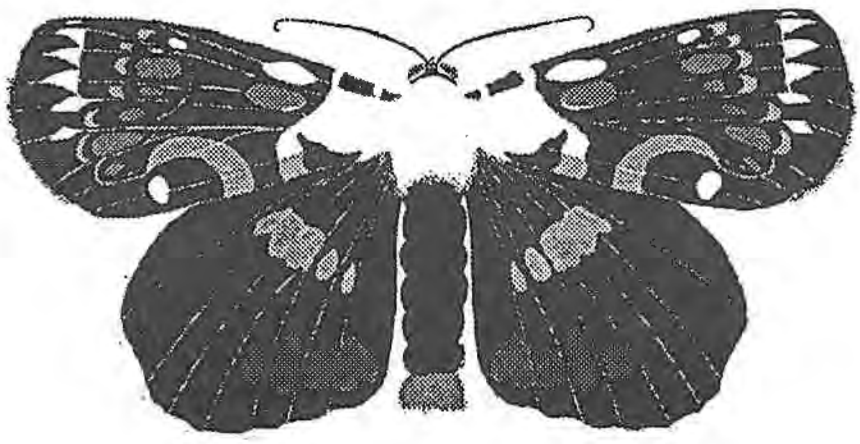
23 - 28 SEPTEMBER 1995

AUSTRALIAN ENTOMOLOGICAL SOCIETY INC.

26TH ANNUAL GENERAL MEETING AND SCIENTIFIC CONFERENCE

FARRER MEMORIAL AGRICULTURAL HIGH SCHOOL
TAMWORTH, NSW, 23 - 28 SEPTEMBER 1995

CONVENORS
Robin Gunning
Royce Holtkamp
John Hosking



The Conference Logo
(drawn by Nerida Coleman)

The logo depicts the painted vine moth, *Agarista agricola* (Donovan), which is found in the Northern Territory and from Cairns, Queensland to central New South Wales. It was one of the most colourful insects we had in our collection at Tamworth.

CONFERENCE SPONSORS

- **Cotton Research and Development Corporation**
- **The Australian Cottongrower**
- **Ciba-Geigy**
- **Crop Care**
- **Hoechst Schering AgrEvo**
- **Integrated Pest Management P/L - Bugs for Bugs**
- **Rhône-Poulenc Rural, Australia**
- **Carl Zeiss**

C.R.D.C.

The Australian cottongrower

ACKNOWLEDGMENTS

The Organising Committee is grateful to NSW Agriculture for support. The Cotton Research and Development Corporation sponsored Dr Ian Denholm's travel to Australia.

Thanks are due to Tourism Tamworth for their assistance in organising this conference. We also thank Marje Balfe, Nerida Coleman, Lyn Deegan, Brett Craswell, Paul Sullivan, Alan Maguire, Phil Christian and Ron Sippel (entomology and weed biological control unit technical staff) at the Tamworth Centre for Crop Improvement who willingly volunteered their time and assistance at various stages of the preparation and running of this conference. Without their help this conferencen would not have been possible.

ORGANISING COMMITTEE

The members of the organising committee will be clearly distinguishable from other delegates by their **red name tags**. If you have any problems or requests please contact one of the members of the organising committee.

CONTENTS

CONFERENCE TIMETABLE

Saturday 23rd September

4:00 - 7:00 pm	Conference registration (Farrer High School)
6:00 - 8:00 pm	Welcoming BBQ and drinks (Farrer High School)

Sunday 24th September

9:00 - 9:30 am	Opening of Conference: Hon. Tony Windsor MP (Member for Tamworth)
	Insect Conservation and Native Insect Ecology
9:30 - 10:30 am	Plenary address: Dr Tim New, Latrobe University
10:30 am - 3:00 pm	Contributed papers
	General Entomology
3:00 - 5:00 pm	Contributed papers
5:15 pm	49th Council Meeting (Farrer High School)
Evening	Special interest group meetings

Monday 25th September

	Cotton Entomology Symposium
8:30 - 11:05 am	Invited and contributed papers
11:05 am - 12:05 pm	Plenary address: Dr Ian Denholm, Rothamsted Experimental Station, UK
12:05 - 5:40 pm	Invited and contributed papers
6:00 pm	26th Annual General Meeting of the Australian Entomological Society

Tuesday 26th September

	Field Trip to Oxley Wild Rivers National Park and Sheba Dams
8:45 am	Pick up participants from Tamworth Towers Motel
9:00 am	Pick up participants from Farrer High School and depart

Wednesday 27th September

	Biological Control and Integrated Control
9:00 am - 12:00 pm	Contributed papers
12:20 - 2:00 pm	Fun Run (approx. 7 km through the grounds of Farrer High School)
	Systematics
2:00 - 3:00 pm	Contributed papers
	Formal poster session and entomological software demonstrations
3:00 - 5:00 pm	Posters on display in multi-function centre at Farrer High School
5:00 pm	50th Council Meeting (Tamworth Towers Motel)
7:30 pm	Conference Dinner (Tamworth RSL Club Conference Centre)

Thursday 28th September

9:00 - 9:30 am	Phil Carne student prize winner
	General Entomology
9:30 am - 12:00 pm	Contributed papers
12:00 pm	Close of Conference

VENUES

Participants are reminded that with the exception of organised lunches and morning and afternoon teas, eating or drinking are not permitted in any lecture hall, classroom or other conference venue at Farrer High School. Farrer High School is a non smoking workplace, and this rule shall be strictly enforced.

The **main hall** at Farrer High School will be the primary venue for oral presentations at this conference. Poster and entomological software displays will be located in the multi-function centre. These venues will be clearly signposted for the convenience of delegates.

The **registration desk** will be located in the multi-function centre and will be open on Saturday 23rd September from 4:00 to 7:00 pm and again on Sunday 24th September from 8:00 to 9:00 am when the conference will be officially opened by the Hon. Tony Windsor MP (Member for Tamworth). Late arrivals are requested to see one of the organising committee who will be distinguishable by their red name tags. The desk will also be manned during breaks in the Scientific Program.

The **Tamworth Towers Motel** is the main accommodation for conference delegates. It is located on the corner of the New England and Oxley Highways (see Tamworth map on back cover) and is approximately 10 km from Farrer High School.

College style accommodation for students is located at Farrer High School. Rooms to be used will be signposted.

The **Annual General Meeting** will be held in the main hall at Farrer High School. The **49th Council Meeting** will be held at Farrer High School and the **50th Council Meeting** will be held in the conference room at Tamworth Towers Motel.

Classrooms at Farrer High School have been organised for **special interest group meetings**. See the organising committee to book one of these rooms. Alternate facilities must be arranged by those organising the meeting.

The **conference dinner** will be held in Tamworth RSL Club's Conference Centre. This is located on the 1st floor of Tamworth RSL, Kable Avenue (see Tamworth map on back cover) and is a short walk from Tamworth Towers Motel.

Coffee and tea will be served outside the multi-function centre. In the case of inclement weather coffee and tea will be moved inside the building. The **welcoming BBQ** will be held on the central lawn area at Farrer High School.

INFORMATION FOR PRESENTERS

Speakers please give your slides to the projectionist at the commencement of either the morning or afternoon sessions. Slides should be clearly labelled with your name. You should introduce yourself to the session chair at least 10 minutes prior to the start of the session and familiarise yourself with the projection equipment controls. Slides will be available for collection at the conclusion of each session. Please ensure that your presentation does not exceed the allocated time of 20 minutes (including questions). Session chairs have been instructed to strictly enforce this time limit.

Poster presentations can be set up at the commencement of the conference following registration. Please use the board that has been allocated to your poster. Posters must be left on display until the conclusion of the formal poster session on Wednesday 27th.

OTHER CONFERENCE INFORMATION

Accompanying persons program A specific program has not been organised for people accompanying conference delegates. Tourism Tamworth (667587), located on the corner of Peel and Murray Streets (map back cover), can assist with brochures, information and bookings.

Airlines For information on flight times and reservations, Qantas and Eastern Australia Airlines can be contacted on 131313, Ansett can be contacted on 131300 and Tamair can be contacted on 615000.

Banks Branches of the major NSW based banks (Advance, ANZ, Commonwealth, National Australia, St George, State NSW and Westpac) can be found along Peel Street (map back cover). These branches have automatic teller facilities that accept most cards.

Bookshops Narnia Bookshop and Angus & Robertson Bookshop are located in Peel Street. Pages Bookshop is located in Tamworth Shoppingworld which is in Bridge Street (map back cover).

Childcare A number of options for childcare are available in Tamworth. Please contact the registration desk for details.

Emergencies In the event of an emergency, assistance is available from the registration desk during conference hours or, after hours, from members of the organising committee - Robin Gunning (662266), Royce Holtkamp (653902) or John Hosking (655990).

Health Pharmacies are located in various shopping centres around Tamworth. Roger Downs Pharmacy is open seven days per week until 8:00 pm and is located in Peel Street. At night, delegates staying at the Tamworth Towers Motel should contact the reception desk if a doctor is required. Resident staff at Farrer High School will also be able to assist after hours. Tamworth Base Hospital is located on the corner of Johnston and Dean Streets (map back cover) and can be contacted on 661722.

Inquiries and Messages The conference registration desk will be open during conference hours. Staff will endeavour to answer your inquiries. A message board will be located in the multi-function centre at Farrer High School. Messages for delegates can be left with the switchboards at the Tamworth Centre for Crop Improvement (067) 631100 and Farrer High School (067) 679211 or facsimiles can be sent to the Tamworth Centre for Crop Improvement on (067) 631222. Please have callers or facsimiles clearly state that you are a delegate at the Entomological Society Conference.

Meals The welcoming BBQ, morning teas, lunches and afternoon teas are included in the registration fee. Dinner can be obtained at any of a number of restaurants and clubs located centrally in Tamworth. Many of these are within easy walking distance of the Tamworth Towers Motel. Feel free to ask any of the organising committee for recommendations.

NRMA Road service is available at all hours by phoning 664713. Interstate visitors who are members of an automobile association in their home state may also use this service.

Parking There is plenty of free parking for vehicles at Farrer High School. Parking is available in most areas of Tamworth CBD. However, some of these are metered or chargeable parking areas and the Parking Police are especially efficient in Tamworth.

Points of Interest (See map back cover) Oxley Park is an area of native vegetation in close proximity to Tamworth, where delegates should feel free to collect insects or walk. If you have an overwhelming desire to pat a kangaroo Endeavour Park marsupial park is available. This area is also a good example of the effect of overgrazing by kangaroos. Oxley Lookout offers spectacular views, both by day and night, of Tamworth and the surrounding district. Other common tourist destinations include historic Calala Cottage, the Country Music Museum and Powerhouse

Museum. See Tourism Tamworth's brochure for opening times and locations. Any delegates desperate to listen to country music can contact Tourism Tamworth for details of current venues etc. If any delegates wish to visit and/or collect in other local native vegetation areas please see a member of the organising committee.

Post Office The two main Tamworth Post Offices are located in Peel Street and in Tamworth Shoppingworld in Bridge Street. There are also several Post Office agencies located in various areas of Tamworth.

Taxis Tamworth Radio Cabs Cooperative can be contacted on 661111.

Telephones Public telephones are available on the grounds of Farrer High School.

Trains Countrylink operate a daily train service to Tamworth from Sydney and return. For information and bookings contact Countrylink reservations on 132232.

Scientific Sessions - Sunday 24th September

9:00 - 9:10 **John Hosking**
Welcoming address

9:10 - 9:30 **Hon. Tony Windsor MP (Member for Tamworth)**
Conference Opening

Insect Conservation and Native Insect Ecology
Chair: Mr Royce Holtkamp (NSW Agriculture)

9:30 - 10:30 **Tim New (La Trobe University)**
Plenary Address: Taxonomic focus and quality control in insect surveys

10:30 - 11:00 **Morning Tea**

11:00 - 11:20 **Lisa Lobry de Bruyn, Sutrisno and Chris Chilcott**
A survey of soil and epegeic invertebrate biodiversity in irrigated cotton under two levels of tillage management and crop rotations

11:20 - 11:40 **M.F. Braby**
Comparative reproductive strategies between seasonal phenotypes in a tropical butterfly: are patterns of egg size variation adaptive?

11:40 - 12:00 **Ingrid Kovacs and Ary Hoffmann**
Variation for pre-reproductive period, size and development among Australian populations of *Helicoverpa punctigera* (Lepidoptera: Noctuidae)

12:00 - 12:20 **A.P. Del Socorro and P.C. Gregg**
A mark-recapture study of *Helicoverpa* spp.

12:20 - 1:20 **Lunch**

Insect Conservation and Native Insect Ecology
Chair: Dr Robin Gunning (NSW Agriculture)

1:20 - 1:40 **Wijesiri Danthanarayana**
Cold hardiness of the lightbrown apple moth (*Epiphyas postvittana* Walk.) (Lepidoptera: Tortricidae) and its geographical variation

1:40 - 2:00 **J.R. Hosking, E.D. Edwards and E.C. Zimmerman**
Lepidoptera and weevils reared from *Uromycladium tepperianum* McAlpine galls collected on *Acacia implexa* Benth. near Chaffey Dam, New South Wales

2:00 - 2:20 **Royce H. Holtkamp and John R. Hosking**
The insect faunae of *Senecio* spp. in New South Wales

2:20 - 2:40 **E. Soleyman-Nejadian**
Diurnal activity patterns of the syrphid flies, *Melangyna viridiceps* and *Simosyrphus grandicornis* (Syrphidae: Diptera)

2:40 - 3:00 **Philip Weinstein**
Documenting the hidden faunae of our tropical caves

3:00 - 3:40 **Afternoon Tea**

General Entomology
Chair: Dr Peter Gregg (University of New England)

3:40 - 4:00 **Trevor K. Crosby**
The 'body in the boot' homicide enquiry - insect evidence on the time of death

4:00 - 4:20 **Murray Fletcher**
Leafhoppers (Hemiptera: Cicadellidae) of quarantiue interest to Australia

4:20 - 4:40 **Bill Frost and Peter Bailey**
Contamiuation by mites of citrus exports to the United States

4:40 - 5:00	**V.A. Drake and LT. Harman** A radar study of locust flight over Longreach Queensland: a preliminary analysis
5:15	**49th Council Meeting (Farrer High School)**

Scientific Sessions - Monday 25th September

Cotton Entomology Symposium

Introduction to insect pests on cotton
Chair: Dr Neil Forrester (NSW Agriculture)

8:30 - 8:45	**Robin Gunning (NSW Agriculture, Convenor)** Welcoming Address
8:45 - 9:00	**Bruce Pyke** The Cotton Research and Development Corporation's perspective
9:00 - 9:15	**Peter Gregg** *Helicoverpa armigera* and *H. punctigera* - the key pests of cotton
9:15 - 9:25	**Ian Hamparsum (ACGRA member)** A cotton grower's perspective
9:25 - 9:35	**Steve Warden (CCA member)** A cotton consultant's viewpoint (1)
9:35 - 9:45	**Chris Lehmann (CCA member)** A cotton consultant's viewpoint (2)
9:45 - 10:00	**Glen Tucker (Crop Care Australasia Pty Ltd)** Carbosulfan for control of soil and sucking pests of cotton
10:00 - 10:15	**<u>Ken McKee</u> and Kevin Bodnaruk (Ciba Australia Ltd)** Diafenthiuron: a new miticide for use on cotton
10:15 - 11:00	**Morning Tea**

Bemisia tabaci: a new whitefly pest?
Chair: Mr Bruce Pyke (Cotton Research and Development Corporation)

11:00 - 11:20	**<u>Robin V. Gunning</u>, Frank J. Byrne and Barry D. Condé** B-biotype *Bemisia tabaci* in Australia
11:20 - 12:20	**<u>Ian Denholm</u> and Mathew Cahill (Department of Biological and Ecological Chemistry, Rothamsted Experimental Station, UK)** **Plenary Address:** Problems with managing the whitefly, *Bemisia tabaci* with particular emphasis on insecticide resistance
12:20 - 12:50	**Rick Roush (Department of Crop Protection, Waite Institute, University of Adelaide)** Managing resistance to whiteflies in glasshouses
12:50 - 2:10	**Lunch**

Management of Bt cotton
Chair: Dr David Murray (Queensland Department of Primary Industries)

2:10 - 2:30	**Gary P. Fitt** Transgenic cottons: an ecological perspective
2:30 - 2:50	**Joanne C. Daly** Management of Bt cottons - a population geneticist's point of view
2:50 - 3:10	**<u>Neil W. Forrester</u>, Gary P. Fitt and Rick Roush** Resistance management options for transgenic cotton
3:10 - 3:30	**<u>Lewis Wilson</u>, Gary P. Fitt, Neil W. Forrester, Deirdre Lally and Robert K. Mensah** Effect of Bt-transgenic cotton on non-target invertebrates
3:30 - 4:15	**Afternoon Tea**

IPM and pest ecology
Chair: Dr Joanne Daly (CSIRO Division of Entomology)

4:15 - 4:35	**Robert K. Mensah and Wendy E. Harris** Use of lucerne (*Medicago sativa* L) in the management of *Creontiades dilutus* (Hemiptera: Miridae) in cotton in Australia
4:35 - 4:55	**David Murray, Richard Lloyd, Brad Scholz, Kerry Rynne, John Marshall, Sarah Thomson and Barry Ingram** Integrated pest management in raingrown cotton
4:55 - 5:15	**Martin Dillon** The implications of pest movement and agroecosystem structure on the effectiveness of pest control strategies: a simulation study
5:15 - 5:35	**Cheryl L. Mares and Gary P. Fitt** What qualities do insects prefer or dislike in a cotton plant?
5:40	**Close of Symposium**
6:00	**26th Annual General Meeting of Australian Entomological Society**

Scientific Sessions - Wednesday 27th September

Biological and Integrated Control
Chair: Dr Robert Spooner-Hart (University of Western Sydney)

9:00 - 9:20 **Lindsay Baggen and Geoff Gurr**
Influence of food provision on biological control of potato tuber moth (*Phthorimaea operculella* Zeller) by *Copidosoma koehleri* Blanchard (Hymenoptera: Encyrtidae)

9:20 - 9:40 **Manthana Khumlekhasing and Gimme Walter**
The importance of mite eggs in the diet of *Frankliniella schultzei* thrips of different stages

9:40 - 10:00 **Ahmad Dahlan and Gordon Gordh**
Biology of *Trichogramma australicum* Girault (Hymenoptera: Trichogrammatidae)

10:00 - 10:20 **Bijan Hatami and Michael Keller**
Comparison of two methods for assessment of parasitism in the cabbage moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae)

10:20 - 11:00 **Morning Tea**

Biological and Integrated Control
Chair: Dr John Hosking (NSW Agriculture)

11:00 - 11:20 **R.K. Peng, K. Christian and K. Webb**
The relationship between native vegetation, the green ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae), and the insect pests in cashew plantations

11:20 - 11:40 **Rahim Muda**
Biological activity and behavioural responses to neem kernel extracts by *Rhyzopertha daminica* (F.) (Coleoptera: Bostrychidae) on stored wheat

11:40 - 12:00 **Graham White, Rachel McFadyen and Don Sands**
Training for reviewers of applications to import and release biocontrol agents

12:00 - 12:20 **P.R. Sullivan and J.R. Hosking**
Biological control of smooth tree pear, *Opuntia vulgaris*, using the cochineal insect, *Dactylopius ceylonicus*, on the north coast of New South Wales

12:20 - 2:00 **Fun Run and Lunch**

Systematics
Chair: Dr Murray Fletcher (NSW Agriculture)

2:00 - 2:20 **Brian Heterick**
Clinal variation in colour in the myrmicine genus *Monamorium* (Hymenoptera: Formicidae) in Australia

2:20 - 2:40 **Margaret A. Schneider**
The subfamily classification of the Conopidae (Diptera) with special reference to the proboscis and the female 'unpaare organ'

2:40 - 3:00 **Dennis G. Black**
Systematics and biogeography of the Australian Siphonotidae (Diplopoda: Polyzoniida)

3:00 - 3:30 **Afternoon Tea**

Poster session and entomological software demonstrations

3:30 - 5:00 See list of posters on page 13

5:00 **50th Council Meeting (Tamworth Towers Motel)**

7:30 **Conference Dinner**

Poster Session - Wednesday 27th September

Amelia Baker
A comparison of soil and litter fauna succession in two subclimax eucalypt stands

Lisa J. Bird and Neil W. Forrester
Biological effects of azadirachtin on two *Helicoverpa* species

Isla Carswell and Robert Spooner-Hart
Laboratory evaluation of *Metarhizium anisopliae* as a potential control of the house fly (*Musca domestica*)

C.H. Eisemann, R.E. Casu, R.D. Pearson, T. Vuocolo and R.L. Tellam
Peritrophic membrane proteins from the larval sheep blowfly eliciting a protective immune response in sheep

Gary P. Fitt, C. Benson and C.L. Mares
Variability of terpenoid aldehydes in cotton and their role in resistance to lepidopteran pests

Gary P. Fitt, R.T. Roush, J.C. Daly and N.W. Forrester
Resistance management strategies for transgenic cotton in Australia

Peter Gillespie
Probit 5 for Windows

Robin V. Gunning
A rapid biochemical method to detect pyrethroid resistant *Helicoverpa armigera* - a tool for resistance management

Robin V. Gunning
Insect survey of Ben Halls Gap State Forest - an Australian Entomological Society sponsored project

Lisa Lobry de Bruyn and Sutrisno
The major impacts of lakebed cropping on invertebrate composition, abundance and activity based on pitfall trapping

Cheryl L. Mares and Gary P. Fitt
Late season sucking insects, the emerging pests of cotton?

Angela E. Nesic
Larval development and egg maturation of *Agrotis infusa* at different photoperiods

R.K. Peng, K. Christian and K. Gibb
Effect of green ants on insect pests in cashew plantations

L. Salehi and M.A. Keller
The response of the parasitic wasp *Orgilus lepidus* to local variation in the density of its host *Phthorimaea operculella*

Trevor D. Semmens
Bumble bees way down under! - Big, Bright, Beautiful and Beneficial

Robert Spooner-Hart
The development and evaluation of a heat tolerant strain of the predatory mite *Phytoseiulus persimilis* A-H

Colin Tann and Gary P. Fitt
Abundance of Helicoverpa pupae under crops in cotton production areas

Brad Wells, Steve Jones and Mike Jackson
INTREPID, a new insecticide-miticide for the cotton industry

Scientific Sessions - Thursday 28th September

9:00 - 9:30 **Phil Carne student prize winner**

General Entomology
Chair:

9:30 - 9:50 **Barry D. Condé, Megan L Connelly, Robin V. Gunning, E.S.C. Smith, Kaye Hergstrom and Rex N. Pitkethley**
Bemisia tabaci (Hemiptera: Aleyrodidae) in Darwin 1970 - 1995

9:50 - 10:10 **Toni M. Withers and Marion O. Harris**
Stimuli influencing patch-leaving behaviour of foraging female hessian flies (*Mayetiola destructor*)

10:10 - 10:30 **Craig Hull and Bronwen Cribb**
Electroantennogram responses of gravid Queensland fruit fly, *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae), to mixtures of volatile chemicals

10:30 - 11:00 **Morning Tea**

11:00 - 11:20 **Kevin Bodnaruk**
Field evaluation of diofenolan: a new insect juvenile hormone for the control of scale insects in citrus

11:20 - 11:40 **Paul Sunnucks, Dinah Hales and Cushla Metcalfe**
Aphids and mitochondrial DNA markers

11:40 - 12:00 **P.J. De Barro**
The genetic and environmental components of host dependant stratification of herbivorous insect populations

12:00 - 12:20 **Conference Summary and Official Closing**

12:20 - 1:20 **Lunch**

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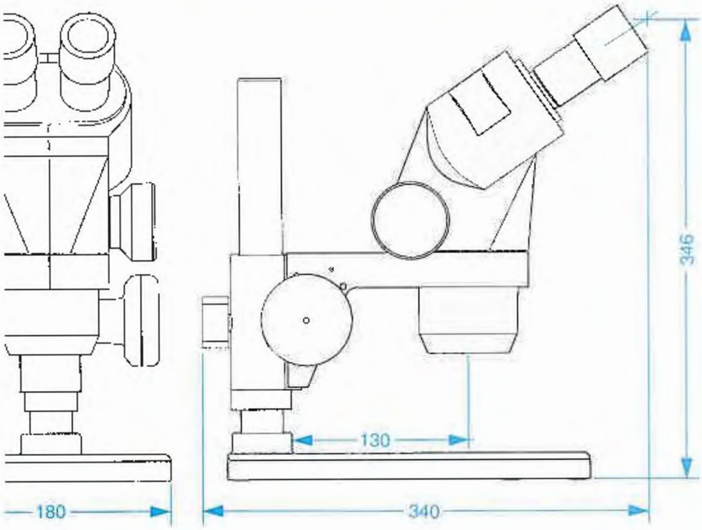

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ABSTRACTS OF PAPERS

INFLUENCE OF FOOD PROVISION ON BIOLOGICAL CONTROL OF POTATO TUBER MOTH (*PHTHORIMAEA OPERCULELLA* ZELLER) BY *COPIDOSOMA KOEHLERI* BLANCHARD (HYMENOPTERA: ENCYRTIDAE)

Lindsay Baggen and Geoff Gurr
Orange Agricultural College, The University of Sydney, PO Box 883, Orange, NSW 2800

We present results from a study aiming to improve the biological control of potato tuber moth (*Phthorimaea operculella* Zeller) by provision of floral resources to natural enemies, with particular reference to the parasitoid *Copidosoma koehleri* Blanchard. Laboratory experimentation has quantified the effect of a range of flowering plants on *C. koehleri* longevity. With access to flowering plants of dill, borage or coriander, adult longevity was significantly greater than in flight cages with water only. A field experiment conducted on the NSW Central Tablelands in the 1994-95 summer, indicated that rates of parasitism by *C. koehleri* of host larvae recovered from foliage and tubers were significantly greater in field cages where parasitoid adults had access to a carbohydrate solution than in cages without such food. This effect was also evident amongst batches of *P. operculella* eggs attached to leaves for a 24 hour period, indicating that this parasitoid is active on foliage. A separate quantification of the benefit extended to *C. koehleri* by a floristically diverse area of plants situated at one end of a potato trial was partly compromised by the early season presence of aphid honeydew and hyperparasitism by *Orgilus lepidus* Muesbeck and *Apanteles subandinus* Blanchard. However, potato moth density and damage to potato foliage and tubers was significantly greater in plots close to the area of flowering plants than at the opposite end of the 20 m long trial site, indicating that the pest was attracted to, and benefited from floral nectar. Results are to be presented from laboratory experiments quantifying the benefit extended to *P. operculella* by different flowering plants.

SYSTEMATICS AND BIOGEOGRAPHY OF THE AUSTRALIAN SIPHONOTIDAE (DIPLOPODA: POLYZONIIDA)

Dennis G. Black
School of Zoology, La Trobe University, Bundoora, Vic 3083

Australian millipedes of the family Siphonotidae are revised. Thirty-eight new species are described, adding to the four already known. Five species, with leglike anterior gonopods, are placed in *Siphonotus* Brandt of the tribe Siphonotini. The remaining species, with fused telopodites on the anterior gonopods, are all placed in the Rhinotini in the new genera *Heterolinotus* (six spp.), *Hesperisiphon* (four spp.), *Minutosiphon* (two spp.), *Dolichorhinotus* (fifteen spp.), *Acuminosiphon* (two spp.), *Vombatotus* (three spp.) and *Megalosiphon* (five spp.). Phylogenetic analysis is carried out to assess the relationships among the eight genera of Australian siphonotids and among the species within some of these. The proposed phylogeny is discussed relative to the current distributions of species and previous vicariance events. The present biogeographic pattern of the family suggests that the Australian component is primarily of Gondwanan origin.

FIELD EVALUATION OF DIOFENOLAN: A NEW INSECT JUVENILE HORMONE FOR THE CONTROL OF SCALE INSECTS IN CITRUS

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Citrus red scale (*Aonidiella aurantii*) is one of the most important citrus pests in Australia. It can cause a down grading of infested fruit and at high populations a loss of tree vigour, defoliation and twig and branch dieback. Citrus red scale is currently controlled by either parasites or

conventional broad spectrum insecticides. Diofenolan is a new insecticide with a novel mode of action. It is a insect juvenile hormone analogue currently being evaluated for the control of Citrus red scale. It acts in the scale insect by disrupting the transformation from first instar crawler to sessile scale. Treated crawlers cannot cast their old larval 'skin'. Affected second instars do not moult to the adult stage. Field trials have been conducted in Australia for three years. It has been found that two applications of diofenolan applied at 10-20 g ai/hL, one month apart, significantly reduced levels of citrus red scale. Levels of control were comparable with current industry standard methidathion applied at 50 g ai/hL. Diofenolan has been found to be highly specific. Consequently, it has little direct effect on many beneficial arthropods. A significant factor where the preservation of beneficial arthropod species is desired. Diofenolan, therefore, may provide a satisfactory alternative control option to the currently used broad spectrum pesticides, particularly, where IPM or insect resistance management programs are in place.

COMPARATIVE REPRODUCTIVE STRATEGIES BETWEEN SEASONAL PHENOTYPES IN A TROPICAL BUTTERFLY: ARE PATTERNS OF EGG SIZE VARIATION ADAPTIVE?

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Adults of *Mycalesis perseus* (Lepidoptera: Satyrinae) exhibit striking phenotypic variation in wing underside eyespot elements. Females in the wet season are characterised by large conspicuous eyespots (wet-season form), while those emerging during the dry season have greatly reduced eyespots (dry-season form). The reproductive biology and breeding phenology of *M. perseus* is complex: wet-season forms are short-lived and usually reproduce directly, whereas dry-season forms remain in reproductive diapause throughout much of the dry-season and do not breed until the first pre-wet-season rains. The reproductive strategies, including aspects of fecundity, egg size and reproductive effort, were compared between each of these forms. Considerable differences were detected: post-diapausing females of the dry-season form had reduced realised and potential fecundity, laid larger eggs, and had a much lower reproductive effort; egg weight also increased with female age in the wet-form but declined in the dry-season form. These findings indicate that diapause imposes a substantial cost to reproduction, possibly as a result of a trade-off or an adjustment in resource allocation between soma (to increase longevity) and reproductive reserves acquired during the larval feeding period. The possible adaptive significance of the egg size variation between the seasonal phenotypes is discussed.

BEMISIA TABACI (HEMIPTERA: ALEYRODIDAE) IN DARWIN 1970 - 1995

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The indigenous sweetpotato whitefly, *Bemisia tabaci* was first recorded in Australia from the Ord River Irrigation Area, Western Australia in 1962. It has probably been present in Darwin from that time. In 1970 and each successive year, tomatoes in the Darwin area have been infected by Australian tomato leaf curl geminivirus (ATLCV). ATLCV is now known to be transmitted by the indigenous whitefly. Presumably, the virus existed and was transmitted between wild plants by the indigenous whitefly prior to 1970. The vector was first detected in Darwin in 1985 and has been observed in low numbers in both glasshouse and field situations in each successive year. The B-biotype sweetpotato whitefly was found for the first time in Australia in large numbers on rockmelons at Darwin during October 1994. This introduction was traced to infested Euphorbia snowflake plants from a Queensland nursery. In July 1995, a second introduction of B-type to the NT was detected on poinsettia from New South Wales. As at July 1995 indigenous whiteflies are distributed throughout the Top End in low numbers while the B-types are in higher populations at a limited number of localities.

CARBOSULFAN FOR CONTROL OF SOIL AND SUCKING PESTS OF COTTON.

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Since 1989 a series of research work has been conducted by Crop Care Australasia and FMC International to evaluate carbosulfan for the control of soil and early season insect pests in cotton. When applied as an in furrow treatment as a granule or spray at planting carbosulfan has shown excellent control of sugarcane wireworm (*Agrypnus variabilis*) and false wireworm (*Pterohelaeus darlingensis*). An in furrow application of carbosulfan has also given control of early season cotton pests such as thrips (*Thrips* spp), jassids (*Austroasca* spp), cotton leafhopper (*Amerasca terraereginae*), and green mirid (*Creontiades dilutus*). Researchers have commented that other pests such as brown flea beetle (*Chaetocnema* sp) and cockroaches are suppressed by carbosulfan. The use of carbosulfan has resulted in increased cotton stands, improved plant vigour and increased dry and fresh weights of the cotton plant. Rates of carbosulfan tested ranged from 0.5-2.0 kg a.i./ha. Insect control and plant responses improved with increasing rate of carbosulfan up to 1.0 kg a.i./ha. Carbosulfan has been compared to aldicarb, chlorpyrifos, imidacloprid, and phorate and has shown equal or improved efficacy in cotton to the above cotton pests. Carbosulfan is a systemic carbamate insecticide which is sold under the tradename of Marshal® (Marshal is the registered trademark of FMC Corporation Philadelphia, USA). Marshal has a relatively low toxicity to mammals compared with other soil active carbamates.

THE 'BODY IN THE BOOT' HOMICIDE ENQUIRY - INSECT EVIDENCE ON THE TIME OF DEATH

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On 2 January 1993 N.Z. Police discovered a badly decomposed body in the luggage compartment of a completely closed Ford Telstar hatchback vehicle parked in a street in Mt Albert, Auckland. Fly maggots had developed on the body, and maggots and puparia were collected from the luggage compartment on 3 January 1993. These were identified as being the European greenbottle, *Lucilia sericata* (Meigen) (Diptera: Calliphoridae), and the common house fly, *Musca domestica* (Linnaeus) (Diptera: Muscidae). The inferred rate of development of the flies suggested that death had occurred 8 or 9 days earlier. Subsequent tests were carried out in the vehicle on the temperatures in the luggage compartment. As well, a pig's head was used to find out the elapsed time before flies oviposited on it in the luggage compartment, and the rate of development of maggots that hatched from the egg masses. These tests showed that death had occurred 9 days before the specimens were collected on 3 January, and had occurred no earlier than 1900 h on 24 December 1992 and no later than 1200 h on 25 December 1992. At the trial the insect evidence was validated as it was established from other evidence that death had occurred in the early hours of 25 December 1992.

BIOLOGY OF *TRICHOGRAMMA AUSTRALICUM* GIRAULT (HYMENOPTERA: TRICHOGRAMMATIDAE)

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Trichogramma australicum Girault were reared on eggs of *Helicoverpa armigera* (Hübner) and the larvae and pre-pupae were studied with a confocal laser scanning microscope. Development of eggs, larvae, pre-pupae and pupae required about 24-26, 24-26, 42-47 and 84-92 hr respectively at 28°C and 75% RH. The eggs of *T. australicum* increased in size during incubation. The larval mandibles did not increase in size. Instead, the fully-formed mandibles became gradually exposed as the larvae grew. The larval exuviae were not found. Therefore, we conclude that *T. australicum* has one larval instar. Staining larvae and pre-pupae with 1% aniline blue in Neisenheimer's induced fluorescence. Stained larvae and pre-pupae gave a clear image of anatomy. The urate bodies appeared on the onset of pre-pupa. Meanwhile, the vitelline membrane of host egg gradually blackened. Legs, wings, antennae, body segmentation, genitalia, compound eyes and ocelli colour became distinct during the pre-pupal stage. Larval integument and mandibles were shed at the onset of pupation. The adult wasps emerged in 182.40 ± 0.40 hr (n = 10) after oviposition. On average 2.80 ± 0.25 (n = 10) wasps emerged from a host egg. The sex ratio was 1 male: 3 females.

MANAGEMENT OF BT COTTONS — A POPULATION GENETICIST'S POINT OF VIEW

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There is no doubt that insects have the capacity to evolve resistance to transgenic plants, given the right conditions. Estimates of the frequencies of potential resistance alleles to Bt in American *Heliothis virescens* are of the order of 10^{-4}. We do not have comparable data for Australian *Helicoverpa* species but it would be prudent to assume that a similar situation occurs here.
We can minimise the risk of resistance to Bt cotton if the following conditions can be met:

1. There should be minimal exposure of pest populations to discriminating concentrations of toxins. This can be achieved when expression of the toxin is stable and predictable under various environmental conditions; and when toxin concentrations exceed that required to kill most heterozygous resistance individuals.
2. Some of the pest population should escape exposure to the toxin. In this case, susceptible individuals can survive in naturally or artificially created refuges. They then can mate with resistant individuals to reduce the frequency of homozygous resistance individuals or immigrant populations can swamp any local resistant populations.
3. Survival of resistant populations can be reduced by other causes of mortality. Natural enemies present in unsprayed cotton can suppress populations surviving in Bt cotton. The use of a late season insecticide on larval populations or the destruction of overwintering pupal populations by cultivation reduce the size of the founding population in the following spring and maximise the benefits achieved by immigration of susceptible populations.

The net result of these above actions is to reduce selection pressure for resistance and to enhance the benefits of gene flow.

COLD HARDINESS OF THE LIGHTBROWN APPLE MOTH (*EPIPHYAS POSTVITTANA* WALK.) (LEPIDOPTERA: TORTRICIDAE) AND ITS GEOGRAPHICAL VARIATION

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This is the first report on the determination of cold hardiness for an Australian native insect. Supercooling point (SCP) varied as a function of developmental stage. Cold hardiness decreased after hatching and then increased in the pupa. Ranking by the SNK test was: male pupa (-20.5°C) < female pupa (-19.5°C) < egg (-18.5°C) < instar II (-17.6°C) < instar IV (-13.9°C) = instar VI (-13.8°C) < instar 3 (-13.2°C) < instar V (-12.2°C). For geographical strains this was Canberra (-14.6°C) = Melbourne (-14.7°C) < Armidale (-17.4°C) < Mildura (-17.9°C). Winter conditioning significantly lowered SCPs, with those of larvae and pupae decreasing significantly from March to August. For most immatures winter feeding was a prerequisite for survival; mortality occurred at temperatures of at least 8°C above the SCPs. The main criterion for survival - the ability of survivors to complete development and emerge as morphologically normal adults with full reproductive competence - was also determined. Many are able to survive continuous exposure to sub-zero temperatures (-1 to -6°C) for periods up to 24 hours, and for 48 hours at -2°C. Survivors did mate and generate viable progeny. Basis of cold hardiness is increased synthesis of trehalose in the -5 to 0°C range; no cryoprotective polyols are involved. Exposure to sub-zero temperatures for two weeks increased trehalose content to 0.4% of larval wet body weight. At this level, trehalose is capable of preventing both freezing and desiccation damage to membranes and proteins.

THE GENETIC AND ENVIRONMENTAL COMPONENTS OF HOST DEPENDANT STRATIFICATION OF HERBIVOROUS INSECT POPULATIONS

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Numerous studies on the biology of various species of herbivorous insect have demonstrated marked variability in fitness among different genotypes with respect to different species of host. However, a firm link between biological variation and population structure at the genetic level has not yet been demonstrated. In an on going study at the University of Southampton, this problem has been addressed by using molecular techniques such as DNA fingerprinting and RAPD-PCR. Here, genetic variation in the population structure of the grain aphid, *Sitobion avenae* (F.), based on host utilisation was demonstrated. The underlying genetic and environmental causes of this variation was then explored using reciprocal host transfer studies to determine whether any penalty in individual fitness was paid as a result of moving between hosts. Finally, the roles that trade-offs in host utilisation and conditioning play in creating the host based population stratification found between wheat and wild grasses in southern England are discussed.

A MARK-RECAPTURE STUDY OF *HELICOVERPA* SPP.

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A mark-recapture experiment to study the local movement of *Helicoverpa punctigera* and *H. armigera*, particularly that of mated females, was conducted at ACRI, Narrabri in November-December, 1994. A chickpea field infested with *Helicoverpa* larvae was sprayed twice with

strontium chloride to serve as the source area. A network of 75 pairs of pheromone traps and 24 light traps was established within a 10km radius of the sprayed field. Moths caught in the traps were analysed for strontium levels using XRF. Determination of pollens from the probosces of these moths by SEM is also underway. Analysis of moths from pupae dug from an unmarked crop indicated a strontium level of up to 7ppm. About 41% of moths from pupae dug from the sprayed chickpea field were marked. Strontium analysis for all moths caught in the traps is not yet completed. Preliminary results showed that of the recaptured females from the light traps, between 50 and 64% of females of both species were marked. The percentage of marked males from the pheromone traps was very low.

PROBLEMS WITH MANAGING THE WHITEFLY, *BEMISIA TABACI* WITH PARTICULAR EMPHASIS ON INSECTICIDE RESISTANCE

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In recent years, the whitefly *Bemisia tabaci* has invaded and become the predominant insect pest of several important arable and horticultural systems. On cotton, it has achieved particular significance in the Americas, North Africa, the Middle East and Pakistan, damaging plants directly through feeding and honeydew deposition, and indirectly through transmission of plant geminiviruses such as cotton leak curl virus. Problems with managing *B. tabaci* arise from its fecundity, mobility (both by active and passive means), extreme polyphagy, and its propensity to develop resistance to insecticides. This resistance now extends to all major chemical groups - pyrethroids, organophosphates, carbamates and cyclodienes - and some newer agents including buprofezin, pyriproxyfen and imidacloprid. Patterns of resistance exhibit geographical variation but show no obvious association with particular whitefly 'biotypes'. Indeed, biochemical and molecular analyses have shown identical resistance genes to occur in both B-type and non B-type populations. This paper will present information on the occurrence and nature of whitefly resistance around the world, explore the utility of different approaches (toxicological, biochemical and molecular) to monitoring for resistance in this species, and review the difficulties and achievements with managing resistance in *B .tabaci* on different crops and different countries.

THE IMPLICATIONS OF PEST MOVEMENT AND AGROECOSYSTEM STRUCTURE ON THE EFFECTIVENESS OF PEST CONTROL STRATEGIES: A SIMULATION STUDY

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The spatial and temporal mosaic of host crops within agroecosystems allow many species of pests to persist within agricultural landscapes. Pest populations residing in patches that escape control may re-infest previously controlled patches. From a regional perspective, the overall effectiveness of various pest control strategies is largely influenced by the movement abilities of the pest, and by the spatial and temporal distribution of host patches upon the landscape. Successful pests have adaptations that enhance their ability to persist within agroecosystems in the face of human applied controls. These adaptations may include high mobility, multiple hop movements, polyphagy, high fecundity, resistance to pesticides, and migratory movements that can enable individuals to arrive into a region from refuges or uncontrolled areas. A spatially explicit simulation model is used to explore the implications of pest movements and agroecosystem structure on the regional effectiveness of a variety of pest control strategies. Pest control strategies with varying levels of efficacy, and with varying extent, frequency and synchronisation of applications are examined for a range of pest movement abilities over a range of agricultural landscapes. It is shown that as the regional coordination of control applications increases, overall pest pressure decreases.

A RADAR STUDY OF LOCUST FLIGHT OVER LONGREACH QUEENSLAND: A PRELIMINARY ANALYSIS

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A fully automated, unattended Insect Monitoring Radar (IMR) is currently operating at Longreach Queensland. It provides an efficient alternative for accumulating season long statistics detailing insect flight. The Longreach site is well suited to monitor the migrations of Australian plague locust (*Chortoicetes terminifera*) and Spur-throated locust (*Austracris guttulosa*). Quantitative analysis of the radar data gives measure of insect height, speed, direction and density. A Doppler Acoustic Radar located alongside the IMR acquires wind vectors at altitudes up to 1km. This data will help estimate destination regions for over-flying locusts. A preliminary examination of the integrated radar data will be discussed. In addition, radar echoes obtained in Longreach will be qualitatively compared with echoes acquired at Canberra ACT.

TRANSGENIC COTTONS: AN ECOLOGICAL PERSPECTIVE

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The deployment in Australia of transgenic cottons expressing Bt toxins will yield major benefits in terms of reduced pesticide dependence of cotton production may also have a number of negative ecological impacts. Of most concern is the possibility of the evolution of resistance to Bt in *Helicoverpa*, for which a number of pre-emptive strategies are being considered (see paper by Neil Forrester et al). In this paper I will consider the ecological characteristics of *Helicoverpa armigera* which might predispose it to resistance development and those characteristics which provide some opportunities for resistance management. In addition I will discuss the range of other potential ecological impacts of Bt cotton. These will include: possible changes in pest status on Bt crops where sucking pests such as mirids might become more significant; potential impacts on non-target species, particularly beneficials; and possibilities of resistance evolution in minor pest Lepidoptera of cotton, (*Earias*, *Spodoptera* and *Crocidosema*), where ecological understanding is poor.

LEAFHOPPERS (HEMIPTERA: CICADELLIDAE) OF QUARANTINE INTEREST TO AUSTRALIA

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Leafhoppers can cause serious damage to plants either by direct feeding damage or by transmission of bacterial, viral or MLO diseases. Introductions of exotic leafhoppers have occurred periodically with varying effects. Damage to elms in Melbourne in 1986 was caused by *Ribautiana ulmi* (Typhlocybinae), the European elm leafhopper. Also in 1986, *Idioscopus niveosparsus* (Idiocerinae) was discovered to have spread from SE Asia to Darnley and Yam Islands in Torres Strait. The recent arrival in Hawaii of *Sophonia rufofascia* (Nirvaninae), a pest of a wide range of vegetable crops in

Asia, has prompted a review of other exotic cicadellid species that may pose a threat to agricultural activity in Australia. Fifty two economically important species were identified as potential imports with sixteen species considered of greatest interest to quarantine. The larger proportion of the Californian species are vectors of Pierce's Disease of grapevine. This is a bacterial disease transmitted with varying degrees of efficiency by virtually all members of the xylem-feeding subfamily Cicadellinae, commonly called "sharpshooters" in the USA. Transovarial transmission has been demonstrated showing that import of plant material containing sharpshooter eggs may introduce the disease. In addition to the Cicadellinae, the review has identified a large number of species of Deltocephalinae that transmit MLO diseases of a wide range of crops and a single species of Typhlocybinae, *Empoasca devastans*, which is a major pest of cotton in India and neighbouring areas. These are potentially serious pest species if introduced to Australia.

RESISTANCE MANAGEMENT OPTIONS FOR TRANSGENIC COTTONS

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It is anticipated that transgenic cottons expressing the Cry 1 Ac toxin from *Bacillus thuringiensis* will be introduced commercially for the 1997 spring planting. Initially only one toxin gene will be available as the CryIIA toxin is not expected to be commercially available until three or so seasons later. There is considerable concern that the potentially intense resistance selection pressure characterising this technology, will very quickly render these single toxin transgenic cottons ineffective through the evolution of Bt resistance. A number of resistance management options will be discussed including seed mixtures, dilution by refugia blocks of conventional cottons or other crops, cultivation of overwintering pupae, supplementary late season insecticidal control, multiple toxins etc.

CONTAMINATION BY MITES OF CITRUS EXPORTS TO THE UNITED STATES.

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The export of navel oranges is seen as one of the keys to developing a more viable citrus industry in Australia. Following granting of fruit fly freedom status by the USDA in 1992, the Riverland district of SA has steadily increased volumes of navel oranges exported to the United States over the past three years. The detection of "actionable" invertebrates including mites of the family Tarsonemidae and Tenuipalpidae, however, lead to the fumigation of roughly 70% of Riverland shipments in 1994. While direct costs associated with MeBr fumigation are substantial (A$80,000 in 1994), of greater concern to Australian exporters is the potential for restriction of access to the United States market, and for damage to Australia's reputation as a supplier of clean, quality produce. A HRDC-funded project has consequently been initiated to investigate the post-harvest disinfestation of oranges, a component of which includes a survey to determine the composition and seasonal dynamics of the Acarine fauna of citrus groves in the Riverland district. The survey work will be extended into the Sunraysia and Riverina districts of NSW in 1996. These areas are currently endeavouring to establish fruit fly freedom status with the USDA, and it is hoped will begin navel exports to the US in the near future. The incidence of a number of phytophagous, predatory and fungivorous mite families in citrus groves in the Riverland district is discussed with reference to their agricultural and quarantine significance.

HELICOVERPA ARMIGERA AND *H. PUNCTIGERA* - THE KEY PESTS OF COTTON

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The key pests of cotton in all cotton growing regions of Australia are *Helicoverpa armigera* (Hübner) and *H. punctigera* (Wallengren). Both species are endemic noctuid moths which feed on the squares and bolls of cotton, causing economic losses in excess of $100 million annually due to the costs of control and lost yield. The problems posed by *Helicoverpa* spp. are due to interactions of some of their fundamental ecological characteristics with the nature of the cotton crop and the way it is produced. The pests are polyphagous, strongly migratory and highly fecund. Outbreaks are difficult to forecast and hard to manage without recourse to insecticides. The economic threshold is low because of the high value of the crop and the nature of the damage. The impact of predators and parasites is limited under commercial conditions, due to ecological characteristics of the pests and the widespread use of broad spectrum insecticides. Despite the difficulties, alternatives to insecticides are urgently needed because of the development of resistance to some chemicals in *H. armigera*, and because of problems associated with residues and the environmental effects of others. This paper will review the nature of the *Helicoverpa* problem in cotton, and briefly discuss the potential for changes in pest management.

B-BIOTYPE *BEMISIA TABACI* (HEMIPTERA: ALEYRODIDAE) IN AUSTRALIA

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B-biotype *Bemisia tabaci* were detected in Australia for the first time in October 1994. Whiteflies collected from a rockmelon crop in Darwin, NT and from a plant nursery in Tamworth, NSW were identified as the Poinsettia or Silverleaf Whitefly, B-Biotype *B. tabaci* (Gennadius) using a diagnostic electrophoretic technique. Naphthyl esterases of individual whiteflies were visualised with the substrate 1-naphthyl butyrate after their separation on polyacrylamide gels. The distinctive isoenzyme profile was consistent with those found in contemporary B-biotype populations from other geographic regions. Overseas the Poinsettia Whitefly has attained primary pest status on cotton, vegetables and ornamentals through the development of insecticide resistance. The advent of this biotype in Australia coincides with the recent geographical expansion of *B. tabaci* through the extensive international trade in plants. An Australia wide survey has shown that B-Biotype *B. tabaci* in Australia are widely distributed in plant nurseries in New South Wales, Queensland, and the Darwin area of the Northern Territory. They have been recorded in Tasmania and are very likely to exist in the other states. Preliminary evaluation of the in vitro effects of organophosphorous (OP) and carbamate insecticides showed a high degree of insensitivity of the target enzyme, acetylcholinesterase. The levels of insensitivity detected are sufficiently high to seriously threaten any effective role for OPs and carbamates in a chemical control program. The likely significance of this whitefly, for cotton in Australia, is discussed.

COMPARISON OF TWO METHODS FOR ASSESSMENT OF PARASITISM IN THE CABBAGE MOTH, *PLUTELLA XYLOSTELLA* (L.) (LEPIDOPTERA: PLUTELLIDAE)

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Cabbage moth (CM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is the most destructive pest of brassicaceous crops in South Australia. Insecticide resistance in CM has led to a search for alternative methods to control this pest. The impact of parasitoids on CM was investigated to determine the importance of these natural enemies as agents of biological control. The impact of the parasitoid *Diadegma semiclausum* Hellen (Hymenoptera: Ichneumonidae) on field populations of the CM was estimated from August 1993 to June 1995 on kale plants using conventional density sampling and a modified recruitment method. Densities of CM larvae peaked at 120/m^2 on 4 November 1994 and 348/m^2 on 6 December 1994. The rate of parasitism ranged from 0% to 26% from late October to late November, and from 3% to 14% during December 1994. In contrast, the rates of parasitism as estimated by the recruitment method were 18%, 11% 25% in November 1994, December 1994 and January 1995, respectively. These results indicate that parasitism by *D. semiclausum*, the main cause of CM mortality, peaked during November and again in early January. Levels of parasitism measured by the conventional density sampling method were somewhat lower than those measured by the recruitment method. It was concluded that the recruitment method gave more accurate estimates of percentage parasitism because total numbers of parasitised and unparasitised CM can be estimated as they enter the pupal stage.

CLINAL VARIATION IN COLOUR IN THE MYRMICINE GENUS *MONOMORIUM* (HYMENOPTERA: FORMICIDAE) IN AUSTRALIA

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The ant genus *Monomorium* is usually considered speciose in Australia, where 50 species and sub-species have been described. These include large graminivorous forms previously referred to *Chelaner*, which is now treated as a synonym of *Monomorium*. Many of these species, however, were distinguished by differences in shape and colour based on few specimens. I now regard less than 20 as valid. Modern taxonomists working with the phylogenetic species concept emphasise the need to assess whether every individual from a putative species carries the entire complement of characters for that taxon. This aspect will be discussed with reference to colour morphs in *Monomorium leae* (Forel), *Monomorium rothsteini* (Forel) and *Monomorium sydneyense* Forel. Possible causes of variation are suggested, with reasons why variability in colour may be regarded as infraspecific in these taxa.

THE INSECT FAUNA OF *SENECIO* SPP. IN NEW SOUTH WALES

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Fireweed, *Senecio madagascariensis*, is an exotic weed species from Madagascar and South Africa which infests hundreds of thousands of hectares of pasture east of the Great Dividing Range. Until 1980, *S. madagascariensis* was regarded as belonging to the Australian native *Senecio lautus* complex. However, native members of this complex are essentially non-weedy. Field studies were conducted in Australia from 1992 to 1995 to determine the insect fauna found on a number of native and introduced *Senecio* spp. Virtually all insects that occur on the *S. lautus* complex have also been reared from *S. madagascariensis*, with in excess of 100 species having been recorded. The taxonomic similarity between the *S. lautus* complex and *S. madagascariensis* is thus paralleled by the similarity in their insect faunae. In contrast, other Australian native *Senecio* spp. such as *S. amygdalifolius*, *S. bipinnatisectus*, *S. biserratus*, *S. gunnii*, *S. linearifolius*, *S. minimus* and *S. quadridentatus*, while having some insect species in common with *S. lautus* and *S. madagascariensis*, have some unique fauna. The implications of the similarity between the insect fauna on the *S. lautus* complex and *S. madagascariensis* to any future biological control campaigns against *S. madagascariensis* are discussed.

LEPIDOPTERA AND WEEVILS REARED FROM *UROMYCLADIUM TEPPERIANUM* MCALPINE GALLS COLLECTED ON *ACACIA IMPLEXA* BENTH. NEAR CHAFFEY DAM, NEW SOUTH WALES

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Sixteen species of Lepidoptera and five species of weevils (Anthribidae, Apionidae and Curculionidae) were reared from *Uromycladium tepperianum* galls collected on *Acacia implexa* from slopes to the north of Chaffey Dam in New South Wales. Galls were collected at monthly intervals from August 1993 to August 1994 and at three monthly intervals from October 1994 to July 1995. Five additional species of weevils (Curculionidae) were collected on galls, two commonly. The latter weevils were either using the galls for shelter or using the fungus as a source of food. The most common Lepidoptera were *Erechthias* sp. nr. *mystacinella* (Tineidae), *Eucosma* sp. (Tortricidae), *Stathmopoda callichrysa* Meyrick (Oecophoridae), *Anarsia* sp. (Gelechiidae) and an unidentified species of Cosmopterigidae. The most common weevils were *Myrmacicelus formicarius* Chevrolat (Apionidae: Myrmacicelinae), *Melanterius costipennis* Lea (Curculionidae: Curculioninae) and an unnamed genus and species of Curculioninae. This study is compared with an earlier study of Lepidoptera reared from *U. tepperianum* galls on *Acacia decurrens* (J. Wendl.) Willd. in Melbourne. Lepidoptera from *U. tepperianum* galls are discussed.

ELECTROANTENNOGRAM RESPONSES OF GRAVID QUEENSLAND FRUIT FLY, *BACTROCERA TRYONI* (FROGGATT) (DIPTERA: TEPHRITIDAE), TO MIXTURES OF VOLATILE CHEMICALS

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Electroantennograms were recorded from gravid Queensland fruit fly in response to mixtures of various volatile chemicals. The electroantennogram method was used to indicate the number of receptor sites that respond to a range of volatile chemicals. Three receptor sites were distinguishable. One site receives methyl butyrate, 2-butanone, 1-hexanol and farnesene; one site receives ethanol; and one site receives n-butyric acid and has an undetermined interaction with ammonia. The mixture of ammonia and n-butyric acid gave a subtractive response which indicates an interaction between these chemicals or their receptors at the cellular or molecular level. The presence of such a limited number of receptor sites is seen as an important part of the peripheral olfactory discrimination process.

THE IMPORTANCE OF MITE EGGS IN THE DIET OF *FRANKLINIELLA SCHULTZEI* THRIPS OF DIFFERENT STAGES.

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The common blossom thrips, *Frankliniella schultzei* Trybom, is frequently thought to feed mainly on flower parts of several plant species. However, interpretation of the dietary requirements of this thrips species were questioned when both larvae and adults fed on two-spotted mite eggs on cotton leaves in the field and laboratory. However, the laboratory observations yielded very variable mite egg consumption rates, which could not be meaningfully interpreted. Therefore, a series of laboratory predation experiments was conducted to investigate the possible influences on thrips predation levels, as well as to quantify the influence of predation on the survival, developmental rate, life span and fecundity of *F. schultzei*. *Frankliniella schultzei* immatures developed successfully both on diets containing leaf tissue and mite eggs and leaf tissue alone. Feeding on leaf tissue and mite eggs in the immature stages lowered the time from egg to adult as well as the percentage mortality. Fecundity was increased and life span was extended over that which occurred on a leaf diet alone. Second-instar larvae consumed significantly more eggs than any other life stage and young second-instar larvae fed on more eggs than did old second-instar larvae. *Frankliniella schultzei* from *M. arboreus* in Brisbane consumed significantly fewer mite eggs than did *F. schultzei* from cotton in Narrabri. Mite eggs that had their webbing removed were consumed at a significantly greater rate than those with webbing intact. The results are discussed in relation to the host plant relationships of *F. schultzei*.

VARIATION FOR PRE-REPRODUCTIVE PERIOD, SIZE AND DEVELOPMENT AMONG AUSTRALIAN POPULATIONS OF *HELICOVERPA PUNCTIGERA* (LEPIDOPTERA: NOCTUIDAE)

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There is evidence that *Helicoverpa punctigera* populations in major cropping areas of eastern Australia receive large influxes of immigrants from inland Australia in early spring. Noctuid moths generally migrate while the adults are sexually immature. Therefore the pre-reproductive period (PRP) provides an indication of the number of nights over which females can express their migratory potential. Environmental factors such as temperature and photoperiod seem to play an important part in the regulation of migration and may have critical effects on PRP. This project had two aims: (1) to characterise genetic variation of PRP in *H. punctigera;* (2) to consider environmental effects on PRP. To examine genetic differences among populations, stocks originating from five geographical localities, with potentially different migratory capacities, were characterized for variation in PRP and life history traits. To determine if there is a genetic basis for any differences observed, crosses between the populations were done. A quantitative genetic approach was also used to examine the genetic contribution to PRP. A selection experiment was carried out to try and change the length of PRP. Preliminary analysis of all these experiments suggest that PRP is not genetically variable, in contrast to similar work on *Spodoptera exempta*. The effects of photoperiod on PRP, size and life history traits were considered. Photoperiod affected the development time of *H. punctigera* but had no affect on PRP. Field heritability is now being assessed for PRP and flight capacity, as measured by tethered flight on a mill.

A SURVEY OF SOIL AND EPEGEIC INVERTEBRATE BIODIVERSITY IN IRRIGATED COTTON UNDER TWO LEVELS OF TILLAGE MANAGEMENT AND CROP ROTATIONS

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Soil cores, and pitfall traps were taken in December and March (1994-1995) to investigate the diversity and seasonal variation in activity of soil and epegeic invertebrates over an irrigated cotton crop growing cycle which had experienced different crop rotations and tillage management. The randomised blocked experimental trial (established since 1985) is located at the Myall Vale Research Station, Narrabri, NSW on grey cracking clay soils. The most abundant invertebrate groups, in descending order, were Collembola, ants, beetles, mites and grasshoppers. Ant species richness was low, with only two genera recorded which were *Iridomyrmex* and *Pheidole* (with two species each). Earwigs and spiders were not abundant, but at least one specimen was recorded per pitfall trap. There was little difference between the three soil tillage management/cropping rotation treatments in terms of invertebrate foraging activity or presence of soil invertebrates. However in December there were some trends with ants, in particular *Pheidole* sp., being most abundant in the minimum tillage plots, and lowest in the maximum tillage plots. Also, Collembola numbers were highest in the wheat-cotton minimum tillage area and lowest in continuous cotton under maximum tillage. In spite of the more favourable habitat/microclimate conditions in March there was a significant decline (> 90%) in abundance of all surface active invertebrate orders which is probably as a result of pesticide spraying. In contrast the soil cores recorded higher levels of invertebrate activity, principally mites and Collembola, in March compared with December. This result could be attributed to the more ambient surface soil temperatures and soil moisture in March compared with December. Nevertheless, abundance of invertebrates in soil cores was low. Invertebrate activity in the soil seems to be controlled by microclimate conditions rather than pesticide usage.

DIAFENTHIURON: A NEW MITICIDE FOR USE IN COTTON

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Diafenthiuron is a thiourea derivative being developed in Australia, by Ciba, as a foliar insecticide/acaricide in cotton used for the control of Two-spotted mites (*Tetranychus spp.*) and Aphids (*Aphis gossypii*). Diafenthiuron is a pro-insecticide, which in the presence of sunlight is transformed to a biologically active carbodiimide. The pesticidal carbodiimide is a potent inhibitor of insect mitochondrial respiration, i.e., energy metabolism. Diafenthiuron has a unique mode of action not shared with any currently available commercial insecticides. There have been no indications of cross-resistance found to other insecticide groups so far. Consequently, diafenthiuron controls all resistant strains of mites and aphids. Diafenthiuron exhibits a high degree of selectivity and as such is a suitable chemical tool for IPM programs in cotton. In local cotton field trials diafenthiuron was found to provide control of all motile stages of mites at least equivalent to current industry standards. Length and degree of control was found to correspond to the level of infestation at treatment. Diafenthiuron has been found to be effective using both ground and aerial application methods at 300 and 400 g ai per hectare respectively.

WHAT QUALITIES DO INSECTS PREFER OR DISLIKE IN A COTTON PLANT?

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Are insects after a good food source with protected hiding places? Cotton is a wise choice as it has a long 4 month fruiting season during which the plant is well maintained with water and nutrients. The cotton HPR program is investigating the influence of plant morphology and biochemistry on pests and beneficial abundance. Field observations of both feeding and predatory insects show the importance of plant morphology influencing the abundance of insects. For example, many live inside the bracts surrounding the fruiting structures where they are protected from weather conditions and surface chemical sprays. Examples of insects that live and feed inside these areas are the nymphs of several Hemipterans: *Creontiades*, *Campylomma*, *Oechelia* and *Nezara*. Adults of several others also dwell there eg *Orius*, *Laius*, various Coccinellids and spiders. The role of plant chemistry is less well understood. Field results based on many cotton varieties grown under 3 management treatments (unsprayed, BT sprayed (heliothis control) and fully sprayed) at 3 sites will be discussed. These results will highlight varietal effects on insect pressure and utilise relative yield as a measure of plant tolerance to sucking pests and *Helicoverpa*. Field observations of *Helicoverpa*. feeding preferences and biochemical analyses of nutrients and secondary compounds will be presented in an attempt to understand some of these patterns.

USE OF LUCERNE (*MEDICAGO SATIVA* L.) IN THE MANAGEMENT OF *CREONTIADES DILUTUS* (HEMIPTERA: MIRIDAE) IN COTTON IN AUSTRALIA

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The green mirid *Creontiades dilutus* (Stål) is one of the most serious early-season pests of cotton in Australia. The cotton industry currently relies on broad spectrum insecticides targeted against *Helicoverpa* spp. to control this pest, which in turn disrupts biological control of other major cotton pests. Field experiments to evaluate the role of lucerne, *Medicago sativa* L. in the management of green mirids on cotton were conducted under mesh house free/no-choice and commercial farm conditions at Norwood near Moree, Auscott and the Australian Cotton Research Institute at Narrabri in New South Wales from 1992 - 94. In the mesh house choice tests and under field conditions, cotton was less preferred to lucerne by *C. dilutus* adults for oviposition resulting in a significantly higher number of eggs laid on lucerne than cotton. However under no-choice tests oviposition on lucerne and cotton and also the survival of mirid nymphs on these plants were not significantly different. These indicated that green mirid adults have a distinct preference for lucerne to cotton. In the absence of lucerne, however, the female will not restrain oviposition but deposit the same number of eggs on cotton. In an experiment where lucerne was planted as strips within commercial cotton, 15 and 35 times fewer mirid adults and nymphs respectively were recorded on cotton compared with cotton without lucerne strips. Again when lucerne was interplanted with commercial cotton under integrated pest management (IPM) regime which had no insecticide sprays against *Helicoverpa* spp. through the season mirid numbers were reduced to levels similar to that achieved by nine conventional insecticide sprays. We conclude that lucerne could be incorporated into an IPM system to control green mirids on cotton.

BIOLOGICAL ACTIVITY AND BEHAVIOURAL RESPONSES TO NEEM KERNEL EXTRACTS BY *RHYZOPERTHA DOMINICA* (F.) (COLEOPTERA: BOSTRICHIDAE) ON STORED WHEAT

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The residual activity of an ethanolic neem kernel extract (ENKE), containing azadirachtin, was evaluated in the laboratory against *Rhyzopertha dominica* (F.), a highly damaging primary pest of stored cereals, on wheat stored up to 48 weeks. On freshly treated grain, the application rate of 5 mg kg^{-1} of azadirachtin was effective in inhibiting F1 progeny production by >98% against three test strains. The minimum application rate of 10 mg kg^{-1} was effective in suppressing >95% of F1 progeny of the multi-resistant strain throughout the 48 weeks storage period, with complete prevention estimated at 75 mg kg^{-1}. The effectiveness of azadirachtin was not synergised by piperonyl butoxide. The results indicate persistency of this emulsifiable neem formulation, and the potential for field evaluation as a grain protectant. The main effect of the ENKE was growth regulatory due to post feeding physiological action affecting oviposition. Applied as grain admixture, deterrent effect of neem is insignificant, as the insects continue to feed normally, presumably due to hunger. Uneven distribution of neem on grain and aggregative adult behaviour affect the efficacy of treatment.

INTEGRATED PEST MANAGEMENT IN RAINGROWN COTTON

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Helicoverpa spp. are the most important obstacles hampering the development of IPM in Australian cotton production. In order to adopt an IPM approach, the industry needs a solid platform on which to base *Helicoverpa* management. Transgenic (Bt) cottons offer exciting prospects, but irrespective of their success there will remain a future need for various components of IPM in both transgenic and conventional cotton production. With IPM in raingrown cotton, our approach was to conserve natural enemies, to make inoculative and/or inundative releases of *Helicoverpa* egg and larval parasitoids, and to rely on Bt sprays when considered necessary. When natural enemies required help, we planned to use a selective, reasonably effective option for *Helicoverpa* control. Experience over the past three seasons has demonstrated that Bt sprays did not fulfil this role, particularly when *Helicoverpa* activity was moderate to high. It was this prospect that led to our revisiting nuclear polyhedrosis viruses (NPV). Trials with NPV during the 1994/95 season have provided a boost for IPM, and a better platform around which parasitoids can be integrated into pest management programs. Food sprays are another exciting development. Success with IPM will be dependent on progress with these options, for it will be only by the removal of disruptive chemical intervention that the full value of natural enemies will be realised.

TAXONOMIC FOCUS AND QUALITY CONTROL IN INSECT SURVEYS

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Detailed, species-level, interpretation of all insect groups in surveys for conservation assessment is rarely (if ever) possible, but reliable taxonomy is a vital parameter of quality control in measuring and comparing 'biodiversity'. The level of taxonomic focus needed for particular survey purposes

is often poorly defined, and sampling regimes are commonly designed without regard for the purposes of any particular survey or for the logistic needs/capability of efficient sample interpretation. Comparisons between sites and surveys are often extremely difficult, and sampling methods may induce strong biases in comparative studies. Likewise, interpretation tends to be 'ad hoc', without sufficient regard for deposition of voucher material for permanent reference, and even the recognition of abundant, nominally well understood species may be difficult or inconsistent. Approaches to increasing the effective taxonomic interpretation of insect surveys for habitat conservation are discussed. The topics include (1) focussing on particular insect groups; (2) development of taxonomic expertise; (3) increasing the complementarity of ecologists and taxonomists, and (4) defining the major outcomes needed from surveys.

THE RELATIONSHIP BETWEEN NATIVE VEGETATION, THE GREEN ANT, *OECOPHYLLA SMARAGDINA* (HYMENOPTERA: FORMICIDAE), AND THE INSECT PESTS IN CASHEW PLANTATIONS

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The effect of native vegetation on the distribution of the green ant, *Oecophylla smaragdina*, and the main insect pests in cashew, *Anacardium occidentale*, plantations in tropical northern Australia was studied by field surveys, field observations and a manipulative field experiment. *O. smaragdina* was an efficient predatory species in cashew plantations, and it significantly reduced the damage caused by the main insect pests of cashews, *Helopeltis pernicialis*, *Amblypelta lutescens*, *Penicillaria jocosatrix* and *Anigraea ochrobasis*. In general, when the trees had more than 4 *O. smaragdina* nests, less than 10% of the flushing shoots were damaged by the four insect pest species. Fierce fights between *O. smaragdina* colonies were a major factor responsible for the changes of *O. smaragdina* population and its colonisation and distribution in cashew plantations. This fighting behaviour of this species has not been well documented in the literature before. Although *O. smaragdina* was abundant on a wide range of the native trees, they preferred *Acacia aulacocarpa* and *Planchonia careya*, and they also thrived on cashew trees. In cashew plantations, *O. smaragdina* preferentially colonised trees with thick canopies irrespective of the tree height. The availability of native trees that were preferable for colonisation by *O. smaragdina* and the distance between the native vegetation and the cashew plantation played an important role in the rate and pattern of colonisation by *O. smaragdina* within the plantation. These factors also indirectly influenced the distribution and abundance of the insect pests of cashews. It is suggested that in the management of modern cashew crops, managers cannot rely on the natural dispersal of *O. smaragdina* to control insect pests. The use of native trees to enhance *O. smaragdina* populations to control cashew insect pests in the future is suggested.

MANAGING RESISTANCE TO WHITEFLIES IN GLASSHOUSES

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Resistance to pesticides is a common problem for pest management in glasshouses, at least part because the crops have low treatment thresholds and the glasshouse environment promotes season-long pest reproduction. Many of the standard tactics for resistance management (such as the preservation of refuges for susceptibility) are inappropriate or ineffective in the glasshouse but many other tactics that could be effective are too rarely applied. These include the use of natural enemies and other non-chemical controls, short persistent pesticides, rotations of pesticides on monthly rather than shorter time periods, and the use of the most effective pesticides only as the

crop nears maturity. In particular, there is a "direction of flow" in glasshouses that offers unique opportunities for management of resistance. Even though these tactics may cost more over the short term, they can be overwhelmingly profitable over the long term. Enhancement of quarantine efforts to keep out more resistant strains of *Bemisia* and other pests out of Australia can also play a major role in resistance management.

THE SUBFAMILY CLASSIFICATION OF THE CONOPIDAE (DIPTERA) WITH SPECIAL REFERENCE TO THE PROBOSCIS AND THE FEMALE 'UNPAARE ORGAN'

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The Conopidae has a worldwide distribution with about 800 described species placed in four subfamilies: Conopinae, Myopinae, Dalmanniinae and Stylogasterinae. Adults feed on nectar. Larvae are solitary internal parasites; those of the first three subfamilies are parasites of adult wasps and bees; the Stylogasterinae are parasites of cockroaches and flies. Characters used to distinguish the subfamilies include the length and number of joints of the proboscis and modifications of the female fifth and sixth sterna to form ventral genital processes - the 'unpaare organ'. Most Conopinae have an elongate, sclerotised, anteriorly-projecting proboscis which can reach three times the length of the head and is jointed or geniculate only at the base. The other three subfamilies are characterised by a second joint at about the middle of the proboscis so that it folds back under the head at rest. In Stylogasterinae the proboscis is very long with setaceous labellae; in Myopinae and Dalmanniinae, the proboscis is short with fleshy labellae. A striking characteristic of most conopids is the modification of the female sternum 5 and to a lesser extent, sternum 6. In Conopinae and Myopinae, sternum 5 is expanded ventrally. The posterior surface and the expanded anterior surface of sternum 6 are variously armed with black, flattened spinules and setae of varying lengths. Stylogasterines and Dalmanniines lack these sternal modifications and have an ovipositor; very long and membranous in the former, short and recurved in the latter. The functional and phylogenetic significance of these structures is discussed.

DIURNAL ACTIVITY PATTERNS OF THE SYRPHID FLIES *MELANGYNA VIRIDICEPS* AND *SIMOSYRPHUS GRANDICORNIS* (SYRPHIDAE:DIPTERA)

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Syrphid flies are clearly an important component in the natural control of aphids. Given previous reports, suggesting different peak times of activity of syrphid flies, diurnal activity patterns of the two native syrphid flies, *Melangyna viridiceps* and *Simosyrphus grandicornis* were investigated on African daisy, Marguerite daisy, and weeds in a rose garden in South Australia in June, July, October and November 1993-1994. On African daisy, the activity of *M. viridiceps* commenced between 9-10 am, peaked mostly around noon and declined rapidly in the afternoon. There was a negative significant relationship between the insect numbers during noon and 2 pm, and the amount of light intensity. With a general increase in temperature in spring, two species were compared. The activity of *M. viridiceps* commenced earlier than *S. grandicornis* and a higher percentage of the *M. viridiceps* population was recorded on Marguerite daisy, whereas more *S. grandicornis* flies were counted on weeds. On days with more than 30°C in November, the peak times of activity were in the morning instead of noon. During hot days, *M. viridiceps* peaked and left the sunny sites earlier than the other species. Some individuals of both species were then observed in the shade of *Acacia* trees. Few individuals of *S. grandicornis* re-started activities in the afternoon, whereas, *M. viridiceps* did not rebound to the field. This indicates that the activity

of the two species is temperature-, light- and plant- dependent which can explain the complexity of previously activity patterns reported.

BIOLOGICAL CONTROL OF SMOOTH TREE PEAR, *OPUNTIA VULGARIS*, USING THE COCHINEAL INSECT, *DACTYLOPIUS CEYLONICUS*, ON THE NORTH COAST OF NEW SOUTH WALES

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Smooth tree pear, *Opuntia vulgaris* Miller, is one of 35 cactus species that have naturalised in Australia. It is thought that Captain Arthur Phillip introduced *O. vulgaris* to Australia from Brazil with the "first fleet" in 1788. By 1913 it had established in every state of Australia. The cochineal insect *Dactylopius ceylonicus* has been successfully used to control *Opuntia vulgaris* in Australia, East Africa, South Africa, India, Sri Lanka and Mauritius. Previous attempts to use *D. ceylonicus* for biological control of *O. vulgaris* resulted in the complaint that this cactus could not be controlled biologically in New South Wales. Romiako Island was chosen as a study site because it is similar to other areas where *O. vulgaris* is a problem on the New South Wales north coast. Populations of *D. ceylonicus* pass through four to five generations per year on Romiako Island. *D. ceylonicus* decreased the size and number of new *O. vulgaris* segments and killed, both directly and indirectly, new and old segments. *D. ceylonicus* infested segments showed increased mortality from soft rot organisms and abiotic factors when compared with uninfested segments.

APHIDS AND MITOCHONDRIAL DNA MARKERS

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Genetic studies of aphid populations have always been extremely difficult because of the lack of visible markers and low level of polymorphism that can be detected using allozymes. This is particularly so in Australia, where many economically important aphids have been accidentally introduced on a small number of occasions and the gene pool can thus be expected to be small. We have been investigating the feasibility of using markers based on mitochondrial DNA polymorphism, and have been concentrating our work on the genus *Sitobion*, in which we know there is intra-specific genetic variation because separate chromosome races occur. In the course of this work we found numerous DNA polymorphisms in the cytochrome oxidase I-II region. Polymorphisms, however, occurred within single aphids, and we infer that they have resulted from transposition of mitochondrial sequence into the nuclear genome. This needs to be taken into account when using mitochondrial population markers. The nuclear copies are valuable for inference about the evolution of mitochondrial sequence. Nuclear copies of mitochondrial sequence seem to occur to a smaller extent in some closely related genera, but are not present throughout the whole tribe Macrosiphini. We have also examined CO I-II sequence in the putative species *Myzus persicae* and *M. antirrhini* and found no differences at all. However, consistent differences were found between spotted aphid (*Therioaphis*) populations with different host plant specificities, and a simple diagnostic test was designed.

DOCUMENTING THE HIDDEN FAUNAE OF OUR TROPICAL CAVES

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Tropical cave faunae are arguably some of the most poorly studied in Australia. Apart from obvious access problems, the lack of easy and reliable sampling techniques has contributed to this apparent neglect. I have recently used a 'wet leaf litter trap' to simulate the influx of nutrients into tropical caves following flooding. Such traps draw out invertebrates from mesocaverns, where they would otherwise remain inaccessible to collectors. A comparative study of sampling techniques has shown this method to collect more species and individuals per hour than any other technique available, making it an ideal tool with which to survey the undocumented faunae of our tropical caves. Using 'wet leaf litter traps', postgraduate students and I have identified (a) a self-sustaining population of troglophilic moths (*Pyralis manihotalis*), whose larvae are guanophilic; (b) geographic variation in the morphology of the tropical cave cockroach *Paratemnopteryx stonei*; and (c) a new species and genus of troglophilic pseudoscorpion in the family Chernetidae. In addition, I have used the traps to study the behavioural ecology of troglophilic cockroaches, which appear to use caves as moisture refugia. Although my simple technological innovation has greatly facilitated our work in tropical cave entomology, more important to this effort is perhaps the drive to study insects "where no man has gone before".

TRAINING FOR REVIEWERS OF APPLICATIONS TO IMPORT AND RELEASE BIOCONTROL AGENTS

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Lack of understanding of biological control concepts and methods by reviewers hampers some of the required formal reviews of applications to import and release biological control agents. This causes delays in granting approvals, partly because of time spent in disputes over interpretation of information. The Centre for Tropical Pest Management is developing a training package to improve decision making by departments and individuals involved in reviewing applications. Both a CAL computer package and a manual will be produced. Issues being addressed include:

* basic concepts and methods in biological control
* positive and negative impacts of biological control, particularly environmental
* aims of the review process
* methods of determining host specificity, and their interpretation
* risk analysis

Reference to theory relevant to host specificity determination, as a basis for explanation and interpretation, raises questions about current practices, particularly for arthropod biological control agents. Factors such as physiological state, prior experience, proximity of the host, or of the host plant of an arthropod target, and genetic variability may all affect responses in host specificity testing. Applicants should consider whether these factors may influence the results of their tests. Input from both reviewers of applications and biological control practitioners is being sought during development of the training package.

EFFECT OF BT-TRANSGENIC COTTON ON NON-TARGET INVERTEBRATES

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The advent of transgenic cotton, containing the Cry 1Ac protein, and its widespread adoption by the cotton industry should lead to a significant reduction in insecticide use for the control of lepidopterous pests, especially *Helicoverpa* spp. This may have several important impacts on pest management in cotton. Firstly, the reduction in insecticide use should lead to increased survival of beneficial populations which may help to reduce the frequency of secondary pest outbreaks. Secondly, reduced pesticide use may lead to changes in the pest status of some non-lepidopterous pests that are currently controlled by insecticides applied for control of *Helicoverpa* spp. In particular the sucking bug complex may increase in significance, requiring control with broad-spectrum disruptive insecticides. Finally, there may be effects of transgenic cotton on other components of the invertebrate fauna. For example any effects on fauna involved in recycling organic matter in cotton fields would be important. The effect of Bt-transgenic cotton on non-target invertebrates is being studied in several large scale field experiments. Initial results and their implications for management of Bt-cotton and for experimental design are discussed.

STIMULI INFLUENCING PATCH-LEAVING BEHAVIOUR OF FORAGING FEMALE HESSIAN FLIES (*MAYETIOLA DESTRUCTOR*)

Toni M. Withers[1] and Marion O. Harris[2]
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An experiment was run to reveal how stimuli, both external and internal, influenced female Hessian fly decisions of when to leave a host patch during oviposition. In the first set of experiments, the foraging behaviour of individual females was observed in plant arrays differing in distance between patches, the size of host plant patches and the ratio of host to non-host patches. Patch times were found to be unrelated to the distance between patches, and unrelated to the number of plants within the patch. However movements to plants within the patch were adjusted according to the number of plants within the patch. Despite this, Hessian flies rarely oviposited on all the available plants within a patch before leaving. Deprivation from oviposition sites did extend the duration of the first patch visit, however levels of responsiveness were reset after a single patch visit. When comparing wheat (host) to oats (non-host) plants, host specific stimuli influenced the duration of patch visits. The rate that eggs were laid was fairly constant on host plants, and was lower on non-host plants. The number of eggs laid in each patch visit was related to the time spent in the patch. Ecological theories that may explain the observed patch-leaving behaviour of female Hessian flies will be discussed.

ABSTRACTS OF POSTERS

A COMPARISON OF SOIL AND LITTER FAUNA SUCCESSION IN TWO SUBCLIMAX EUCALYPT STANDS

Amelia Baker
The University of New England, Armidale, NSW 2351

Invertebrate fauna of soil and litter have an important role in decomposing organic matter and cycling minerals and nutrients through ecosystems. A comparison was made between the soil and litter fauna occurring in new regrowth and old regrowth sub-climax eucalypt stands during autumn and winter. The colonisation and succession of fauna that occurred in a standard sterilised litter placed at both sites was also compared. The pattern of fauna abundance in the natural litter differed to that in the sterilised litter. The abundance of natural fauna at both sites showed an overall decreasing trend over the study period due to decreasing temperatures, rainfall and the onset of drought conditions. As the sterilised litter decomposed, each succession of fauna increased in abundance despite the climatic conditions. A significantly greater abundance of soil and litter fauna occurred at the old regrowth site than the new regrowth site in both sterile and natural samples from all collections. This may be due to the later successional stage of old regrowth vegetation where greater fauna numbers have built up over time. Greater fauna diversity of the natural litter samples occurred in the new regrowth site possibly due to the wider variety of niches made available during vegetation regeneration. Acarina and Collembola dominated the natural samples at both sites over the study. Coleopteran, dipteran and lepidopteran larvae and cryptostigmatid mites were most common in the sterilised samples at both sites. The dominant taxa varied over the study in the sterilised samples, apparently following the successional stages involved in the decomposition process.

BIOLOGICAL EFFECTS OF AZADIRACHTIN ON TWO *HELICOVERPA* SPECIES

Lisa J. Bird and Neil W. Forrester
NSW Agriculture, Australian Cotton Research Institute, Narrabri, NSW 2390

Azadirachtin is a bioactive compound isolated from the neem tree *Azadirachta indica* (Meliaceae). Azadirachtin has a diverse range of biological effects in insects including growth disruption, moulting inhibition, reduced fecundity, repellency, antifeeding and anti-oviposition activity. The physiological effects of azadirachtin are consistent between species while behaviour modifying effects vary considerably. The present study investigates the biological effects of neem seed powder (27-30% azadirachtin) by topical application of 1µl of azadirachtin/acetone solution per 30-40 mg fourth instar larva of the cotton bollworm *Helicoverpa armigera* (Hübner) and the native budworm *Helicoverpa punctigera* (Wallengren). The LD50 for azadirachtin was determined for both species at weekly intervals from 21 to 49 days. Larvae were considered to be dead if they were unable to move in a coordinated manner when prodded from behind. Larval growth rates were monitored and rates of development to the pupal and adult stages were recorded. Reproductive fitness (fertility and fecundity) was also assessed (*H. punctigera* only). *H. punctigera* was found to be generally more sensitive to the effects of azadirachtin than *H. armigera*. Larval growth retardation and moult inhibition occurred at significantly lower doses in *H. punctigera*. The average LD50 for *H. armigera* at 42 days was 7.35 µg/larva (three colonies tested) and for *H. punctigera* 0.37 µg/larva (two colonies tested). This indicates an approximately 20 times greater susceptibility to topically applied azadirachtin in *H. punctigera*. The response of *H. armigera* to azadirachtin was independent of the strain's resistance status to synthetic pyrethroids, endosulfan or parathion.

LABORATORY EVALUATION OF *METARHIZIUM ANISOPLIAE* AS A POTENTIAL CONTROL OF THE HOUSE FLY (*MUSCA DOMESTICA*)

Isla Carswell and Robert Spooner-Hart
University of Western Sydney, Hawkesbury, Richmond, NSW 2753

In recent years, there has been renewed interest in entomological biological control. Research has included the role of naturally occurring entomogenous fungi such as *Metarhizium* spp. in the regulation or suppression of populations of insect pests. Entomogenous fungi, as artificially produced microbial insecticides, may become key factors in the ecology of many important invertebrate pests. The pathogenicity of the entomopathogenic fungi, *Metarhizium anisopliae*, isolate FI 369, was assessed for both sexes of the adult house fly (*Musca domestica*), under laboratory conditions. Flies were anaesthetized and separated by sex. Treatments included a nil treatment control, 0.01% aqueous solution of Tween-80, and aqueous suspensions of 1×10^8, 1×10^7, 1×10^6, 1×10^5, 1×10^4 conidia/ml. 1.0 µl of suspensions ($\cong 1 \times 10^5$ to 1×10^1 conidia/ fly) were applied to the ventral surface of the abdomen of 3-5 day old flies. They were then incubated in the dark at 20°C, 25°C or 30°C with a relative humidity over 80%. All flies were fed *ad libitum*. Mortality was assessed at 24 hourly intervals for nine days. In treatment applications of conidia, except 1×10^1 conidia/fly at 20°C, there resulted a significantly higher mortality than the nil treatment control and Tween-80 treatments. Application of 1×10^5 conidia/fly resulted in the highest mortality at all temperatures and at 25°C and 30°C all flies were dead at 8 days. No significant difference of mortality was found between the sexes.

PERITROPHIC MEMBRANE PROTEINS FROM THE LARVAL SHEEP BLOWFLY ELICITING A PROTECTIVE IMMUNE RESPONSE IN SHEEP

C.H. Eisemann, R.E. Casu, R.D. Pearson, T. Vuocolo and R.L. Tellam
CSIRO Division of Tropical Animal Production, Long Pocket Laboratories, Private Mail Bag No.3, PO Indooroopilly, Qld 4068

Several proteins (peritrophins) have been isolated from peritrophic membrane (PM) of larvae of the sheep blowfly *Lucilia cuprina* (Wied.). When injected into sheep, these peritrophins elicit the production of specific antibodies which, after ingestion by feeding blowfly larvae, cause retardation of their growth and in severe cases, mortality of the larvae. Most ingested antibodies remain functional in the anterior third of the midgut, where anti-peritrophin antibodies bind to the continuously-forming PM. Tracer studies employing electron microscopy have indicated that PM affected in this way exhibits substantially reduced permeability to macromolecules. It is hypothesized that this reduced permeability hampers penetration across the PM by newly-secreted digestive enzymes from the ectoperitrophic into the endoperitrophic space and by nutrient macromolecules in the opposite direction. This leads to reduced utilization of ingested nutrients by the larva and a consequent starvation effect. Three of the isolated peritrophins have been characterized and recombinant forms which elicit protective immune responses in sheep have been produced using bacterial and baculovirus-insect cell expression systems. These three peritrophins are structurally related, being glycoproteins each having five copies of a domain characterized by a specific register of six cysteines. Compositional details of two peritrophins (44 and 95) are presented.

Biological Control Tactics

Integrated Pest Management p/l is an Australian company dedicated to concepts of IPM - a philosophy which aims to reduce the reliance on conventional pesticides while maintaining product quality. With 15 years experience in this field IPM p/l has led the way in developing alternative pest management strategies.

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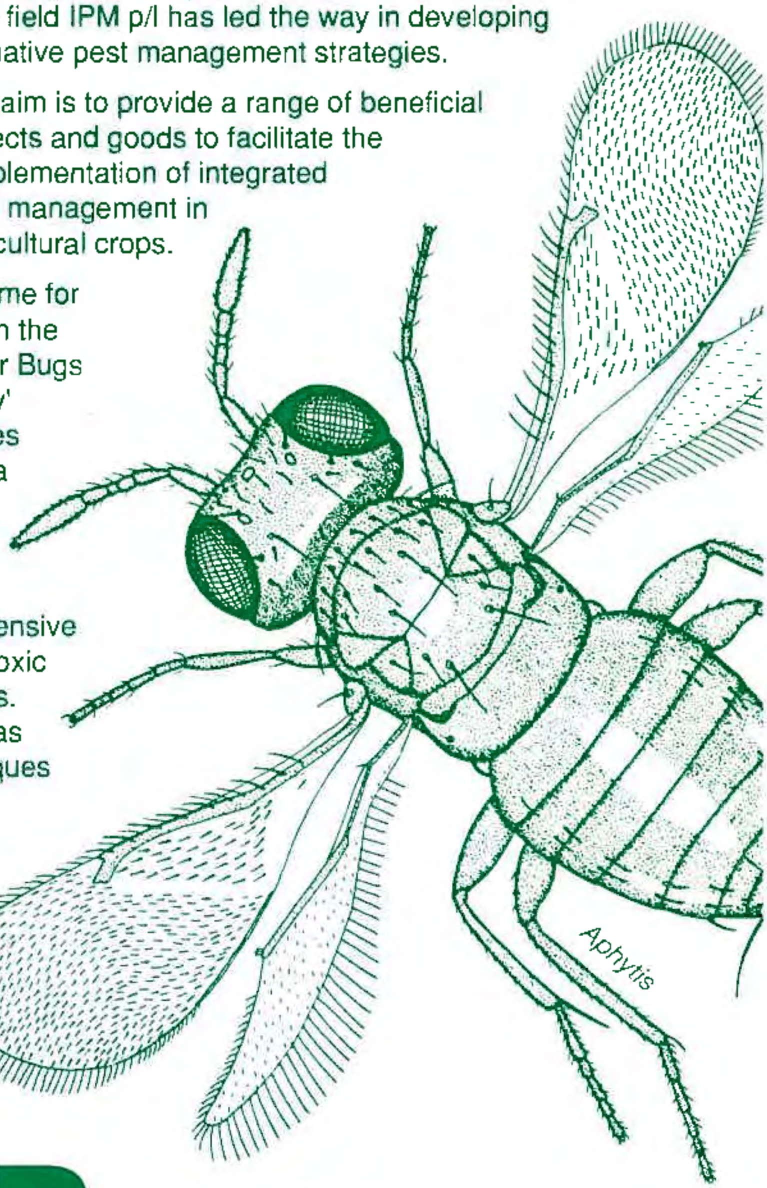

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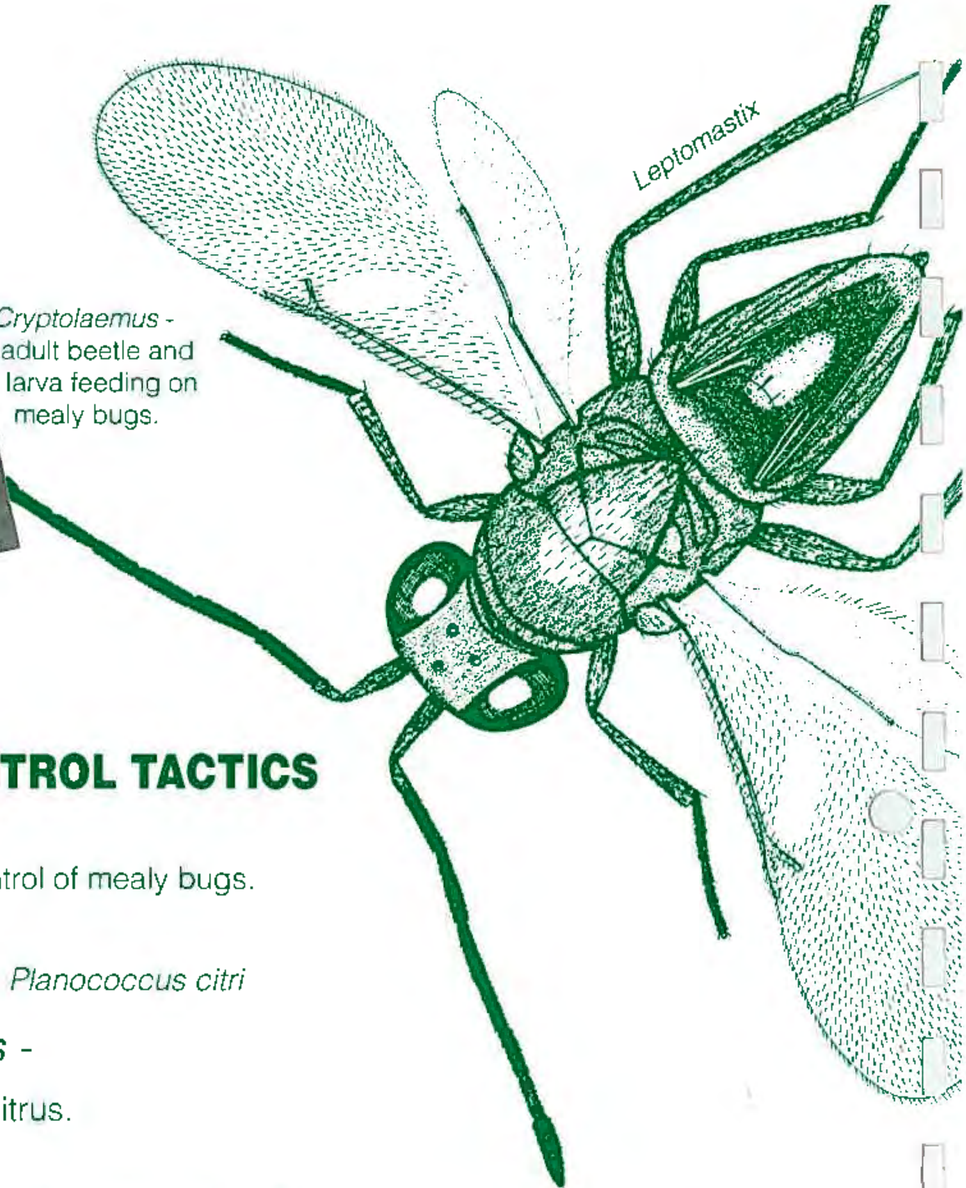
Cryptolaemus - adult beetle and larva feeding on mealy bugs.



BIOLOGICAL CONTROL TACTICS

Cryptolaemus -
Ladybird beetles for the control of mealy bugs.

Leptomastix -
Parasites of the mealy bug - *Planococcus citri*

Aphytis lingnanensis -

Parasites of red scale in citrus.

Lindorus -
Ladybird beetles for the control of armoured scale insects.

Q Fly Lure -
Salt free attractant for the control of Queensland fruit fly.

Q Fly Traps -
For monitoring Queensland fruit fly.

Stickem -
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Sticky Traps -
For the monitoring and control of some flying pests.

Female *Leptomastix dactylopii*

Male *Leptomastix dactylopii* - parasitic wasp

VARIABILITY OF TERPENOID ALDEHYDES IN COTTON AND THEIR ROLE IN RESISTANCE TO LEPIDOPTERAN PESTS

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[2] University of Western Sydney, Richmond, NSW

Various species of cotton, *Gossypium* spp. are rich in secondary compounds including terpenoid aldehydes, volatile terpenes, sesquiterpenoid quinones and condensed tannins. In cultivated cotton (*Gossypium hirsutum*) the best known secondary compounds are the terpenoid aldehydes, gossypol, and the related "heliocides". While the evolutionary role of these compounds is not clear, they are all toxic to a range of Lepidopteran larvae, including the major pests of cotton, *Helicoverpa* spp. We are attempting to utilise these biochemical resistance factors to enhance the pest tolerance of commercial cotton cultivars. Biochemical studies with commercial varieties and selected breeding lines have shown considerable variability among plant structures within varieties and between varieties in the relative concentration of terpenoid aldehydes (TA's); gossypol concentrations are highest in young flowerbuds, while leaves are highest in hemigossypolone and bollcoats are exceptionally rich in heliocides. These patterns of TA concentration can be related to larval feeding patterns, with structures rich in TA's generally being avoided. There may be a 2-3 fold range in concentration of gossypol and other TA's among varieties. This variability is reflected in laboratory bioassays where larval growth rates are directly related to TA composition and content, and in field plots where high terpenoid lines support markedly lower infestations of pest Lepidoptera, suffer less damage and consequently perform relatively better when unprotected. However, pest resistance based on defensive secondary compounds has been consistently associated with lower yield potential. Crosses of high terpenoid lines with high yielding commercial varieties are being used to overcome this cost.

RESISTANCE MANAGEMENT STRATEGIES FOR TRANSGENIC COTTON IN AUSTRALIA.

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Transgenic cottons expressing insecticidal proteins from *Bacillus thuringiensis* subsp. *kurstaki* will soon be commercialised in Australia. Given the strong selection pressure which will be applied to field populations of the target pests (*Helicoverpa* spp.) by Bt cotton, the potential for the rapid evolution of resistance is a real concern. Pre-emptive resistance management strategies, based on the use of refugia to maintain susceptibles in local populations and high expression of Bt toxins in the plants sufficient to kill all susceptible and most heterozygous resistant larvae, are now being researched. Empirical data from field studies of the efficacy of Bt cottons in Australia and of various refugia options will be presented. Consideration of resistance risks with minor Lepidopteran pests will also be highlighted. The refugia/high dose strategy will be integrated with other tactics (cultivation of crop residues, monitoring of Bt resistance levels, strategic use of non-disruptive chemicals, future pyramiding of other insecticidal proteins) to provide a basis for sustained exploitation of transgenic technology in the Australian cotton industry.

PROBIT 5 FOR WINDOWS

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The relationship between observed mortality and the concentration of pesticide is vitally important in the formulation of most effective dosages, and in measuring any resistance to a pesticide. This fact has become critical in the effective management of many insect pests through the correct implementation of chemical sprays especially when the spray is used as part of an IPM program. This computer program was developed to provide a simple, user friendly estimation of probit regressions, the measure most commonly used to express this relationship. This package is a simple windows based utility, designed to quickly and accurately perform single tier probit analysis on mortality data. Features include fully editable data points, operation in Iterative and Non-Iterative Modes, ability to set number of iterations (Iterative Mode only), full Error Correction facilities (including where control mortality is greater than observed mortality, Heterogeneity factor including colour changes with increased heterogeneity of data, ability to edit Fiducial Limits, ability to graph and print probit regressions as well as printing and graphing of results. The code for this program follows that of Finney, D.J. (1971) (*Probit Analysis.* Cambridge University Press) and has been tested against examples given by Finney with similar results.

A RAPID BIOCHEMICAL METHOD TO DETECT PYRETHROID RESISTANT *HELICOVERPA ARMIGERA* - A TOOL FOR RESISTANCE MANAGEMENT

Robin V. Gunning
The Tamworth Centre for Crop Improvement, RMB 944, Tamworth, NSW 2340

A rapid biochemical test to detect individual pyrethroid resistant *H. armigera* has been devised. Pyrethroid resistant *H. armigera* have additional esterase enzymes which are absent in susceptible individuals. The enzymes bind to and metabolise pyrethroids. Esterase titre is correlated to increasing toxicological resistance. Using an assay for total esterase, a rapid biochemical test for pyrethroid resistance in individual *H. armigera* has been devised. The microplate assay can be read by eye and gives good discrimination between resistant variants and susceptible individuals. Correlations between pyrethroid resistance frequencies determined by biochemical or conventional bioassay methods are excellent. The biochemical assay is faster, easier and more informative than conventional bioassay. The biochemical assay can be done in the field as a "spot test" and provides a robust and easily accessible method for representing the resistance of field populations. Simpler and more informative resistance detection methods will allow for improved *H. armigera* resistance management.

INSECT SURVEY OF BEN HALLS GAP STATE FOREST - AN AUSTRALIAN ENTOMOLOGICAL SOCIETY SPONSORED PROJECT

Robin V. Gunning
The Tamworth Centre for Crop Improvement, RMB 944, Tamworth, NSW 2340

Ben Halls Gap State Forest is a tiny, high nutrient, wet sclerophyll, old growth forest on the top of the great dividing range, some 60 km south-east of Tamworth. The forest has been assessed as of exceptionally high nature conservation value and will shortly be gazetted as a Nature Reserve under the control of the NSW National Parks and Wildlife Service. An insect survey of Ben Halls Gap Forest was made possible by an Australian Entomological Society Research Award.

THE MAJOR IMPACTS OF LAKEBED CROPPING ON INVERTEBRATE COMPOSITION, ABUNDANCE AND ACTIVITY BASED ON PITFALL TRAPPING

Lisa Lobry de Bruyn and Sutrisno
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Pitfall traps were taken in March 1994 on two lakebeds - Rotten and Bohda - where graziers engage in opportunistic wheat cropping. The study area is located north of Walgett in northern New South Wales . The soils of all the study sites are grey, non-sodic, medium to heavy cracking clays. The purpose of the survey was to ascertain the invertebrate composition, relative abundance and activity in four habitat types - cropped land - newly cultivated and stubble retained, uncropped and Coolibah woodland. There were 12 invertebrate orders which were prevalent in both cropped and uncropped areas of Bohda and Rotten plain. With increasing vegetation complexity - both in structure and species - there was greater diversity of ant species. In the Coolibah woodland adjacent to the uncropped areas there were groups of ant species (*Camponotus* spp., *Iridomyrmex greensladei*, solitary predators) which clearly require woodland vegetation for resources/habitat needs, and were very rarely recorded elsewhere. There was minimal interaction between ant species recorded in the uncropped and Coolibah areas of the lakebeds. The conversion of the lakebeds into cropping has led to a simplification of the ant fauna to one or two species which were of only minor importance in the uncropped areas. There has been an 80% reduction in ant species richness in the cropped areas. The dominant ant in the cropped areas was *Iridomyrmex sp. M1*, and it builds small, temporary, aggregated (<1 mm in diameter nest entrance hole) nests. In cropped areas where the stubble has been retained ant species richness was higher than in the newly cultivated areas. The seed collecting species - *Pheidole* spp. were more abundant in the uncropped and Coolibah woodland areas of both lakebeds. Spiders were another group which were found in equal abundance whether cropped or uncropped. The abundance of beetles showed a very distinct pattern with the greatest abundance in cropped areas and lower numbers in uncropped areas.

LATE SEASON SUCKING INSECTS, THE EMERGING PESTS OF COTTON?

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Experiments with unsprayed cotton over the last few years have highlighted a number of sucking pests which may cause damage during the final stages of boll ripening. These insects include *Nezara viridula* (green vegetable bug), *Tectocoris diophthalmus* (cotton harlequin bug), *Dysdercus sidae* (pale cotton stainer) and *Oxycarenus luctuosus* (cotton seed bug). These sucking insects damage seeds, cause lint staining and cause the bolls to not open fully resulting in yield losses with machine picking. Lint quality is also downgraded at the gin and severe financial penalties may occur. In conventionally sprayed cotton the pesticides applied for control of other pests have normally controlled these insects, so they have not previously been apparent as a significant threat to the crop. However, with the introduction of BT cottons with less chemical sprays and no in-built tolerance to sucking insects, the significance of these pests will need to be re-considered. We will present evidence of the types of damage caused to maturing bolls, its potential economic consequences and some preliminary data on the potential abundance of late season suckers.

LARVAL DEVELOPMENT AND EGG MATURATION OF *AGROTIS INFUSA* AT DIFFERENT PHOTOPERIODS

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Laboratory experiments were conducted to study larval growth and egg development of *Agrotis infusa* under varying lengths of scotophase. Neonate larvae were transferred to three photoperiodic conditions, 16:8 LD, 14:10 LD and 12:12 LD at 25°C. Head capsule widths were measured weekly until pupation. Emergent female moths were kept at the same photoperiod at which they developed as larvae. Females ranging in age from zero (just emerged) to five nights were dissected and egg diameter and position (within ovaries, oviduct, etc) were recorded. Results suggest that egg maturation is accelerated by a longer scotophase.

EFFECT OF GREEN ANTS ON INSECT PESTS IN CASHEW PLANTATIONS

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There are three main insect pest species in cashew plantations in the Northern Territory, which cause enormous damage to cashew growing tips, foliar and floral flush, apples and nuts every year. They are the tea mosquito bug (*Helopeltis pernicialisi*), the fruit spotting bug (*Amblypelta lutescens*) and the mango tip borer (*Penicillaria jocosatrix*). Green ants are found to be effective predators of these pests.

THE RESPONSE OF THE PARASITIC WASP *ORGILUS LEPIDUS* TO LOCAL VARIATION IN THE DENSITY OF ITS HOST *PHTHORIMAEA OPERCULELLA*

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Dept. of Crop Protection, Waite Campus, University of Adelaide

The potato tuber moth *Phthorimaea operculella* Zeller (PTM) is an important cosmopolitan pest of potatoes. *Orgilus lepidus* Muesbeck is one of six introduced parasitoids of PTM that are established in Australia. While this wasp may attack and forage preferentially on potatoes at all densities, it spends more time searching in patches of higher host density. A field experiment was carried out to determine whether female wasps oviposit randomly or in a discriminatory fashion in response to local variation in host density. Three potato plots were established each with host densities of 10, 20, 40, 80 and 160 1 day old larval PTM per plot, and 60 to 73% of these larvae established on the plants. Ten to 14 gravid female *O. lepidus* were released and the percentage parasitism was determined after 6 hours. The experiment was replicated four times. The rate of parasitism by *O. lepidus* ranged from 22% in low density infestations (10 & 20 PTM released per plot) to 72% in high density (80 & 160 PTM released per plot). *O. lepidus* exhibited a clear density-dependent response to local variation in host density. The results suggest that searching wasps are primarily influenced by the density of unparasitised hosts.

BUMBLE BEES WAY DOWN UNDER! - BIG, BRIGHT, BEAUTIFUL AND BENEFICIAL

Trevor D. Semmens
Dept. of Primary Industries and Fisheries, GPO Box 192B, Hobart, Tas. 7001

The bumble bee *Bombus terrestris* (L.) was first found in Battery Point in Tasmania (and it was in fact a first sighting in Australia) in February 1992. Since that time it has established itself and spread throughout Hobart and nearby areas. Its value is as a plant pollinator. Thus far 129 species of plants have been observed as being visited by the bee - 122 introduced and 7 native species. It is felt that it will increase pollination of introduced plants and has good prospects for use in glasshouse production, particularly of tomatoes.

THE DEVELOPMENT AND EVALUATION OF A HEAT TOLERANT STRAIN OF THE PREDATORY MITE *PHYTOSEIULUS PERSIMILIS* A-H

Robert Spooner-Hart
University of Western Sydney, Hawkesbury, Richmond, NSW 2753

The predatory mite *P. persimilis* has been used extensively overseas and in Australia as a major component in integrated pest mite control (IMC) programs, targeted primarily at twospotted mite, *Tetranychus urticae*, a major horticultural pest. A major limit to success of IMC is the poor performance of *P. persimilis* under high temperatures and low humidity conditions often experienced in Australian crop production. In an attempt to develop strains with greater heat tolerance field strains of *P. persimilis* were collected and cultured in the laboratory. Young gravid females were subjected to conditions of 39°C and approx. 70% RH for 4-7 hours. Survivors were cultured, pooled and subjected to three further selections. The pooled cultures were subsequently pressured in a glasshouse with fluctuating diurnal temperatures of 20-42°C and RH 20-60%. Bioassay under the test conditions described above showed significantly higher survival ($P \leq 0.01$) in the heat selected strain than in both the standard commercial strain and the original field strains. However, fecundity of this selected tolerant strain was found to be significantly lower ($P \leq 0.01$) than that of the standard strain at 20°C and 25°C , limiting its efficacy under these temperatures.

ABUNDANCE OF HELICOVERPA PUPAE UNDER CROPS IN COTTON PRODUCTION AREAS

Colin Tann and Gary P. Fitt
CSIRO Division of Entomology, Australian Cotton Research Institute, PO Box 59, Narrabri, NSW 2390

Helicoverpa armigera and *H. punctigera* are major pests of cotton and several other field crops. Studies on the abundance and survival of overwintering pupae in cotton growing areas of northern NSW have shown the importance of these pupae in the evolution of resistance to pesticides. A high proportion of the overwintering pupal population occurs under cotton crops, they are almost exclusively *H. armigera*, and they carry high levels of pyrethroid resistance. Cultivation to destroy these pupae has been advocated as a tool in resistance management. With the impending release of transgenic *Bt* cottons, various crop and non-crop "refuges" will become increasingly important in providing a reservoir of susceptible moths to assist in resistance management. Consequently we have extended our studies of pupal abundance in order to quantify the value of a range of crops as potential refuges. Here we present data on the levels of overwintering pupae, and the relative abundance of pupae under spring and summer grown crops through northern NSW and southern Queensland over the last two years.

INTREPID, A NEW INSECTICIDE-MITICIDE FOR THE COTTON INDUSTRY

Brad Wells, Steve Jones and Mike Jackson
Cyanamid Australia Pty. Limited

INTREPID insecticide-miticide (numbered compound AC 303,630, and marketed under the name of PIRATE and STALKER in the USA) contains the active ingredient chlorfenapyr and belongs to a new class of chemistry that was discovered at American Cyanamid Company's Agricultural Research Centre in Princeton, New Jersey. INTREPID is highly active via ingestion, possessing contact activity, and provides residual activity on plants. This compound has demonstrated a broad spectrum of pesticidal activity on many economic pests worldwide. Initial studies have shown this compound to be equally effective against resistant and susceptible insect and mite species. Small plot studies and laboratory studies have shown it has only a slight effect on beneficial species. Laboratory studies also show that INTREPID is effective against pests that are resistant to many other compounds and that there is no indication of multiple or cross-resistance. Control of *Tetranychus* spp. and *Helicoverpa* spp. by INTREPID has been equal to or better than that provided by the standard miticides and larvicides. INTREPID does not enhance population increases of *Aphis gossypii* , such as the synthetic pyrethroids. The compound is immobile in soils and therefore it will not have a tendency to leach. These findings, together with the compound's unique mode of action, make INTREPID a very good candidate for integrated pest management and resistance management programmes in cotton.

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	Number	Description	Price
TUBE	E97020	156 gram tube	$ 5.25
CAULKING TUBE	E97010	283 gram caulking tube	$ 7.60

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Number	Description	Price
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