SIP Newsletter for June 2009

Latest on the Utah Meeting

Founder's and Plenary Lectures

Membership News

Newsletter for June 2009

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Cover image

A bollworm, *Helicoverpa zea,* on cotton (photo by Alex Yelich, University of Arizona). For more information see Bruce Tabashnik's article on page 10.

From the President

Spring has sprung in the Northern Hemisphere which means field work or gardening for many of us while the converse is true for those in the Southern Hemisphere. It is nice to feel a bit of warmth here in Lethbridge after an unseasonably cool May. Finally my lettuce seeds are sprouting!

Meeting organizers Rosalind James and Don Roberts are putting the finishing touches to the program & abstracts for the 42nd annual meetings of the Society in Park City, Utah. An e-mail will be sent to members and registrants as soon as the program is made available on-line. The "Meetings at a Glance" should already be available by the time you receive this newsletter. Over 300 abstracts have been received and room bookings are progressing well. Please book soon to ensure you receive the room type and rate of your choice. The Organizing Committee did a superb job of obtaining some very reasonable rates. Airfares at this time are still also cheap. Reserve your flights now before airfares start to rise along with the rise in the cost of fuel. Visit www.utahSIP.org for the latest details on the meeting.

Council was pleased to accept the Meetings Committee's recommendation for Halifax, Canada as the venue for the 44th annual meetings in 2011 under the chairmanship of Susan Bjornson at St Mary's University. Halifax is a focus point for a large east coast marine crustacean fishery and this should provide the Society an opportunity to entice marine crustacean pathologists back into the Society, especially now that we have our new Division on Pathogens of Beneficial and other Non-pest Invertebrates. So after tasting Turkish delights in 2010, we'll have the opportunity to eat lobster in Nova Scotia in 2011. The Meetings Committee is till awaiting firm proposals for 2012.

Our membership renewals are at a little lower than 85% based on last year's membership numbers, however with the raise in membership fees, this was to be expected. We hope to gain a few more members in Park City. Unfortunately interest rates are still falling so that return on investment is not very high. On a brighter note, over $2,000 was added to the Martignoni Fund and over $500 to the Lomer Fund from member contributions. An auction will be held at the BBQ in Park City with proceeds used to cover the shortfall in these two awards, with any excess used to further increase the principle in these funds. These awards should once again become self-sustainable once interest rates climb back to 4% or so. Please inform Fernando Vega if you are offering an item for auction. Details can be found elsewhere in this newsletter.

On a sad note, in this newsletter you will find the Obituary of Claire Vidal, who died at the young age of 40 leaving behind a 9-yr old daughter. Claire was Jacques Fargues' student while I was on my study leave in Jacques' laboratory, 1995-96. Lerry Lacey was on her Research Committee and John Vandenberg acted as the external examiner for her thesis. Although not very active in the Society, Claire was a hard working scientist and was poised to take over Jacques program upon his recent retirement.

A letter of condolence was sent to Claire's parents on behalf of the Society.

The website is constantly being upgraded by Cecilia under the watchful eyes of David Shapiro-Ilan and his Publication Committee. Betty Davidson and her History Committee have started to upload past obituaries. If you have any suggestions for improving the website, or notice any material that is obsolete, please contact David at David.Shapiro@ars.usda.gov.

I'm looking forward to seeing many of you in Park City.

Mark Goettel

SIP President

Newsletter Editorial

How time flies! Judith and I are on our sixth Newsletter, with our co-Editorship starting way back in December 2007 after the Quebec meeting. SIP is now hurtling towards the meeting in Park City, Utah, which - from this distance - appears to be coming along smoothly and problem-free thanks to the efforts of Rosalind James, Don Roberts and their colleagues (just remember to have a post-meeting party!).

In this issue, we have an update on local arrangements for the Utah meeting along with tasters for the Founder's and Plenary lectures.

We have a new feature with an article from one of the SIP Divisions. We would like to encourage officers and members in the various Divisions to submit short science articles, opinion pieces or regional commentaries for this section – get in touch if you have any contributions you think may be suitable for this section.

Also, we would very much like to obtain articles about current developments on microbial control products for the section on Industry News.

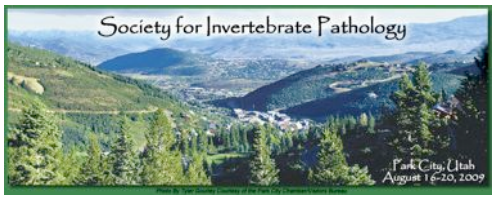
By the time you read this Newsletter, it may be too late to enter the Photo Competition, but let us know if you have ideas for other competitions we could run.

Paresh Shah & Judith Pell

Newsletter co-Editors

42nd Annual Meeting, Aug. 16-20,

Park City, Utah, USA



Program

The program of presentations and posters is available on the conference web site at www.utahSIP.org.

The symposia and workshops have been scheduled with excellent speakers. In addition, we have accepted many excellent contributed papers and posters. You won't want to miss the Plenary Symposium, "*The Host-Pathogen Dance: Interactions between Insect Hosts and Their Pathogens*." Invited speakers are Bruce Tabashnik, Michael Bidochka, and Michael Strand.

Conference Registration

Register online at www.utahsip.org by July 3 to get the early-bird rate! Late registration fees apply after that date. On-site registration begins Sunday, August 16.

Cancellation of Conference Registration – must be received in writing by August 2 in order to receive a refund, less a $75 processing fee. No refunds will be made after this date. Substitutions are always accepted.

Lodging

Make your reservations online as soon as possible to secure the room of your choice and to receive the special group rates posted on the conference web site at https://gc.synxis.com/rez.aspx?Hotel=15051&Chain=6463&Group=25H2YK&arrive=8/1/2009 . Special room rates will be available on an as available basis until July 13.

You may also call toll-free at 1-888-226-9667 or direct at 1-435-615-3360 and refer to the group name **SIP 2009** or the **Group ID number 25H2YK**. Remember, all three hotels at The Canyons Resort are entirely non-smoking properties including the restaurant and lounge areas.

SIP room rates are valid from 13 to 23 August.

Travel

Attendees should fly directly into the Salt Lake City International Airport (SLC), which is a hub for Delta Airlines. It is approximately 30 minutes drive from The Canyons Resort. All major U.S. rental car companies are available at the Salt Lake International Airport for those who may wish to rent a car.

Shuttle to the Hotel

Make shuttle reservations with *All Resort Express* online at https://www.allresort.com/CorporateGroups/Reservations.aspx?grpid=5948&tmpid=4838&tmpl=1

Round trip rates are $70 per adult and $52 per child (under age 12) for a shared-ride van. Park City offers free bus transportation within town limits, including to and from The Canyons Resort once per hour.

Visas and Invitation Letters

The U.S. Government requires that Visas be obtained by visitors from most nations. Please visit the following web site for more information: http://travel.state.gov/visa/visa_1750.html.

If you need a personal letter of invitation to SIP 2009, please contact Lisa Anderson at Lisa.anderson@usu.edu.

Bring the Family

The Grand Summit Hotel features on-site daycare for children ages 6 weeks to 6 years of age. Little Adventures Children's Center is a state licensed daycare facility providing fun, age-appropriate activities. Call ahead for reservations as well as daily and hourly rates, 1-435-615-8036.

Climate & Elevation

The summer climate is moderate and dry - with brilliant blue skies and breathtaking mountains. August highs average 80˚F (27˚C) and lows about 50˚F (10˚C). The base of The Canyons Resort is 6800 ft (2070 m), and the peak is 9990 ft (3045 m).

H1N1 Flu (Swine Flu)

The H1N1 flu has not become as extensive as feared, and it has not caused severe flu in the USA. The epidemiologists are saying it is "similar to seasonal flu", and expect the USA case numbers to reduce significantly in our upcoming typically 'non-flu' summer season.

Meals

The conference registration fee includes the Sunday evening mixer, continental breakfast Monday through Thursday; lunch on Monday/Wednesday/Thursday; dinner on Monday and Wednesday, Tuesday evening BBQ, and Thursday's closing banquet.

All included meals will be served on-site at the Grand Summit Hotel, except the Tuesday BBQ which will be held on the beautiful mountainside at Red Pine Lodge, just a scenic gondola ride away! A companion meal package is also available for purchase.

Excursion & 5K Fun Run/Walk

The optional Tuesday Excursion at the Utah Olympic Park will feature the exciting *Flying Ace Productions' Aerial Show*. Future and former Olympians will ski down the steep incline at speeds up to 35 miles an hour, then launch up to 70 feet in

the air, performing amazing flips, twists and turns, before a soft landing in the state of the art swimming pool below.

The 5K run will be held Tuesday after the Excursion and before the BBQ. Launching from the Red Pine Lodge, the trail will pass through alpine forests at approximately 8000 ft (2438 m) altitude. Get ready to run or walk because it is a fantastic site!

We are ready to accommodate you for another fantastic SIP Meeting

Rosalind James & Don Roberts

Program Co-Chairs

SIP 2009
Park City, Utah
Exploring the host/pathogen dance!

Auction planned for Park City, Utah

Once again we will hold a lively auction of goods and services during the barbecue. Michael Brownbridge, our "Auctioneer Extraordinaire", will cajole you to loosen your wallets and somehow have a good time doing it. And chances are you'll get something unique and valuable out of the deal.

Proceeds from the auction will benefit the Society but all of the fun will be yours. If you wish to donate an item or a service, or need ideas for these, please contact Fernando E. Vega at fernando.vega@ars.usda.gov.

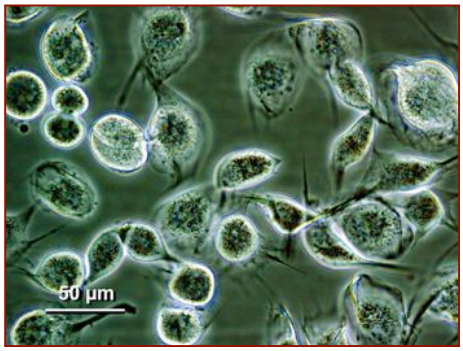
Methods for Developing Insect Cell Lines:

A Laboratory Workshop

8 am to 4 pm, Sunday 16 August, 2009

Utah Valley University Wasatch Campus,

Heber City, Utah



Tn368 cells

A hands-on workshop on Invertebrate Cell Culture lead by Dr. Dwight Lynn, INSell Consulting, will be held immediately prior to the SIP Park City meeting. The workshop, sponsored by the Virus Division, will be comprised of an introductory lecture on the technicalities of making insect and invertebrate cell lines, followed by hands-on laboratory sessions. The Wasatch Campus is a 15 min. drive from the SIP meeting site and can be reached from The Canyons Resort by hotel shuttle.

Registration for workshop

Participants should register for this workshop when they register for the SIP 2009 meeting. Seats are limited to 20 however, so *early registration is strongly encouraged*. The fee for the workshop ($150 for students, $250 for others) includes:

1) a day of hands on training and instruction from an internationally renowned expert

2) protocols for establishing insect cell lines from embryos

3) a CD of related publications

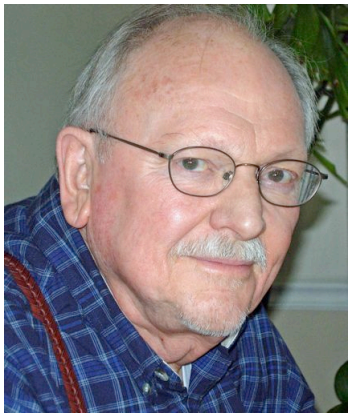
4) dissection equipment

Dr. Dwight Lynn, INSell Consulting, worked for 25 years with USDA-ARS and is an internationally recognized expert in the establishment of tissue derived and embryonic insect cell lines.

He has established some 40 cell lines from 15 species of Lepidoptera, Coleoptera, and Hymenoptera for the study of insect diseases. Dr. Lynn, trained by Dr. W. Frederick Hink, a world-renowned insect cell culturist, has authored or co-authored more than 80 research papers and 10 book chapters.

Founder's Lecture Honoree:

Donald Roberts



Dr. Donald (Don) Roberts, this year's Founders' Lecture Honoree has had a long and distinguished career that includes not only being one of the most productive contributors to the field of insect pathology, but also a visionary apostle of biocontrol in the developing world. Don has trained, inspired, provided resources and leadership for many insect pathologists over many years, and has been one of the most pervasively influential founding members of the SIP.

Don was born in Phoenix, Arizona, in 1933. He lived in Phoenix through high school and two years of university training. He moved to Utah to attend Brigham Young University, where he completed a B.S. degree in 1957 with a major in zoology and a minor in botany. Don obtained a Master's degree from Iowa State University, working on the biology and chemical control of *Evora hemidesma*, a microlepidopteran leaf roller. A turning point in Don's career followed, during his doctoral research. From 1959-1964, under the guidance of Drs. E.A. Steinhaus and M.E. Martignoni at the University of California in Berkeley, Don established a life-long interest in insect pathology. Don's doctoral dissertation concerned production of toxins, bioassay, and induction of mutations in a fungus, *Metarhizium anisopliae*. These are areas of concern to insect pathologists today, forty-five years later. Don obtained a postdoctoral fellowship from NSF (1964-1965) to work at the Swiss Federal Institute of Technology in Zurich with Dr. G. Benz, where he expanded his work on *M. anisopliae* toxins.

From 1965 through 1996, Don was employed by the Boyce Thompson Institute for Plant Research (BTI) rising from Assistant to Full Rank Insect Pathologist by 1974. In 1996, BTI appointed Don the Roy A. Young Scientist (Chair Scientist). Don was also an Adjunct Professor in both the Departments of Entomology, and Plant Pathology at Cornell University.

To promote the field of insect pathology, in 1979 Don proposed the formation of the Insect Pathology Resource Center based at BTI; but including scientists from Cornell University and the USDA. With Don's coordination, this organization made Ithaca an internationally acclaimed center for insect pathology. Over his 31 years at Boyce Thompson, Don's research interests included entomopathogenic fungi, fungal toxins, molecular biology of fungi, insect poxviruses, pathogens of medically important arthropods, and microbial control of insects (with particular emphasis on developing nations). Don's expertise in the field of insect pathology is very broad and he is universally recognized as a world authority. In particular, Don's laboratory has been the center of much of the research on fungal entomopathogens done in the last few decades.

Don retired from the BTI in 1997, but went to work as a Research Professor at the Department of Biology, Utah State University. Don's research at Utah has included the biology and identification of possible biocontrol agents for the Mormon cricket (*Anabrus simplex*) and grasshoppers, including analysis of soil samples from 15 western USA states for new entomopathogenic fungal isolates; studying the molecular targets of abiotic factors that reduce the persistence of biocontrol agents in field conditions; and developing monoclonal antibodies to detect a parasite, *Myxobolus cerebralis*, of fish (trout) and aquatic worms (*Tubifex*). In this year of Don's honor, his research laboratory at Utah State has a staff of 8, and grant funding totaling more than $200,000 pa.

Don has published more than 250 papers on insect pathology and has edited many books and monographs. He has been speaker and/or organizer of more than 200 symposia, conferences workshops, plus numerous seminars worldwide on various topics in insect pathology. Don has worked cooperatively with many scientists throughout his career. He has published with more than 130 of these collaborators, a group which represents 15 nations and includes 28 postdoctoral researchers.

Don has had many international consultancies, such as research in Nigeria on mosquito control with fungi through the World Health Organization during the 1970s; work sponsored by the Rockefeller Foundation and the NSF (1976-1978) in India on survey, production, and field application of a nucleopolyhedrosis virus infecting an agricultural pest, *Heliothis armigera*; advisory and survey work for the Brazilian government (1978-81) on the use of fungi for control of pasture spittlebugs; and a Brazil-based project supported by the USAID Bean/Cowpea CRSP with the collaboration of EMBRAPA (a Brazilian agricultural research organization) on the development of insect pathogens for control of cowpea pests and training of Latin Americans in insect pathology (1981-1992). He collaborated with the International Rice Research Institute in the Philippines with support from USAID and the J.S. Noyes Foundation (1987-1990). Don has served as a "goodwill ambassador" for invertebrate pathology on the World Health Organization Scientific Working Group on Biological Control of Insect Vectors of Disease, WHO Special program on Research and Training in Tropical Diseases, as well as on the United Nations' Development Program's external advisory committee for ecologically sustainable cassava plant protection in West Africa and South America. Don has served or led teams that reviewed a number of prominent insect pathology projects, including two international desert-locust-control projects in the 1990's.

Among the numerous national and international awards Don has received a Fulbright Senior Research Scholarship to Australia (1985); the L.O. Howard Distinguished Achievement Award (1989), the highest award of the Entomological Society

of America (Eastern Branch); and the singular honor, awarded by the Entomological Society of Brazil in 1996, of Honorary Member (Membro Honorario).

Don has played a pivotal role in the development of SIP over the last 40 years and has served with distinction as Program Chair, Meetings Board Chair, Vice President, President (1988-1990), and Ad-Hoc Treasurer in 1990-1991. He has been involved in the organization of several annual meetings, including this year's meeting in Utah. Don has also worked tirelessly behind the scenes to promote the interests and goals of the Society. Conversations with Don about the pursuit of Science, the history of invertebrate pathology, and approaches to achieving microbial control of pests have been a great help to many members of SIP, besides those who have directly collaborated with him. In cases where Don felt he couldn't himself adequately advise, he functioned as the Society's scholar, being a superior resource person who could always suggest who to contact or who might be able to contribute expertise to a research problem.

Don was chosen to deliver the Founders' Lecture at the 1996 meeting of SIP in Cordoba, Spain, he was made Honorary Member of SIP in 1998, and he has been selected as the Honoree for the Founders' Lecture this year (2009). These are the three highest honors the Society can bestow. To mark his scientific contribution to invertebrate pathology, and his mentorship of so many invertebrate pathologists, the newly recognized *Metarhizium robertsii* has been named in his honor.

In 1959, Don married Mae Strand, his life-long partner, and they celebrated their fiftieth wedding anniversary in June. They have two children and three grandchildren.

Founder's Lecturer:

Ray St. Leger

Dr. Raymond J. St. Leger completed his B.Sc at Exeter University (UK) and his M.S degree (in entomology) at Birkbeck College, University of London. Raymond's childhood interests were in insects, reptiles and other life forms some people find distressing. Like many people who are fascinated by insects the only way he could get paid to study them was by finding ways to kill them. Therefore, when Raymond went to Bath University to do his Ph.D, it was in insect pathology. He was fortunate with his two supervisors. First, the insect pathologist Dr Keith Charnley, noted for his studies on the infection processes of *Metarhizium anisopliae*, and second the plant pathologist Dr. Richard Cooper, who had established that growing pathogenic fungi on plant cell walls was a fine way to study the spectrum of enzyme activities they produce to infect their hosts. Raymond, therefore, commenced his studies on insect pathogens by growing them up on insect cuticles and following up the most interesting leads.

Raymond came to America in 1987 after receiving a telephone invitation from Dr. Donald Roberts. Thus commenced a very happy and productive ten-year collaboration at the Boyce Thompson Institute. During this time, Raymond went from being a post-doc to a center scientist and Adjunct Assistant Professor at Cornell University. Working with Don, Raymond helped establish *M. anisopliae* as the best characterized of the entomopathogenic fungi at the molecular and biochemical levels, and a model system for the study of invertebrate-fungus-plant interactions. Under Don's leadership, BTI in the 1990's was a stellar place to do research on insect pathogenic fungi, and Raymond met many who were or would become top researchers in insect mycology and important members of SIP, including Drs. Ann Hajek, Tariq Butt, Steve Wraight, Alice Churchill, Mark Goettel, Richard Humber, John Vandenberg and Mike Bidochka. Raymond co-authored research papers and reviews with many of these researchers. In addition, Raymond benefited from the presence at BTI of the innovative Drs. Bob Granados, Alan Woods and Gary Blizzard, as at that time studies on the molecular genetics of baculoviruses were way ahead of those on insect pathogenic fungi.

In 1997, with Don Roberts "retiring" to resume hard work in Utah, Raymond went to Maryland University as an Associate Professor. He was promoted to full professor in 2001; and, with the help of letters from colleagues in SIP, was named a Distinguished Scholar and Teacher in 2009. Raymond has taught an introductory course in biology and graduate/honors courses in Invertebrate Pathology and Biotechnology. He currently teaches genetics to 200+ putative pre-meds. He has

also participated in several workshops worldwide that involved his teaching students on biotechnology, insect pathology and biocontrol. Raymond has pursued collaborative projects at several international laboratories, particularly in China and Colombia and often with former post-docs. A current research project led by Dr. Chengshu Wang (Shanghai Institute of Sciences) involves genomic sequencing of several insect pathogenic fungi. Raymond has been a consultant to many private and public concerns, including the USDA, the US State Department and the Organization of American States. Raymond served on the Bill Gates funded National Academies Committee to study technologies to benefit farmers in SubSaharan Africa and South Asia (2007). He prepared the sections on insects and fungal pest control, as well as energy policy and technologies.

Raymond is presently an Associate Editor of *The Journal of Invertebrate pathology*. He has published 108 scientific papers on fungal pathogens of plants, animals and insects, and on the reactions of insects to infection. He is the author of 27 chapters in books on diseases, the insect cuticle, biological control and biotechnology. Raymond's dominating research interest has been in insect mycology and primarily directed towards understanding the biochemistry and molecular biology of entomopathogenic fungi. Recent studies have employed *Metarhizium anisopliae* as a vehicle to carry genes encoding spider and scorpion toxins into insects. However, many of Raymond's studies have employed *M. anisopliae* as a model for understanding how fungi respond to changing environments, initiate host invasion, colonize insect tissues, and counter host immune responses. Studies have included genome-wide analysis of the changes in gene expression accompanying infection and other disease processes, and investigations of the genetic circuitry that regulates and executes this program. These studies have also addressed the origins of intraspecific differences (gene loss/gain, modulation of gene expression) and the mechanisms by which novel pathogens emerge to identify the molecular basis of adaptation (one of the "Holy Grails" of evolutionary biology). Current projects include field trials of genetically modified fungal pathogens exploiting easily identifiable marker genes, functional genomic tools for identifying genetic changes, and genes that are implicated in soil survival and pathogenicity to provide the first detailed knowledge of movement, persistence and modes of genetic change in transgenic fungi.

SIP Membership

At time of press, paid-up membership of SIP is 348 full members, 31 student members, 47 Emeritus and 13 Honorary Members. The total of 439 members is lower than last year when the Society had 527. 17% of full members and 33% of students have not renewed their membership. If you know any of these people then please encourage them to renew their membership.

Are you eligible for Emeritus Membership?

Every year the Membership Committee receives a number of requests for Emeritus Membership. However, there are likely to be members that are eligible who have not contacted the membership committee. To qualify as an Emeritus Member you must fulfil the following criteria:

- Full Member in good standing for at least 20 consecutive years or Charter Member or Founding Member in good standing

- Retired from regular and remunerative professional work

Emeritus Members are exempt from the payment of membership dues but retain all the rights of Full Members.

If you are eligible for Emeritus Membership please contact the Chair of the Membership Committee, Helen Roy, at hele@ceh.ac.uk.

Do you know anyone who would benefit from Endowed Membership?

SIP has the facility to provide Endowed Membership for scientists who may be experiencing financial difficulties. If you know of someone who would benefit from Endowed Membership please contact the Chair of the Membership Committee, Helen Roy, at hele@ceh.ac.uk.

Journal Discounts for SIP Members

Journal for Invertebrate Pathology AND Biocontrol Science and Technology

SIP members can now enjoy the benefit of discounts on both Journal for Invertebrate Pathology (US$106.00) and Biocontrol Science and Technology (from US$262 / £149 to US$279.00 / £158). To take advantage of the discounted rate for Biocontrol Science and Technology, contact Taylor and Francis' customer service department at: Subscriptions@TandF.co.uk.

To subscribe to the Journal for Invertebrate Pathology, simply designate your preference when you renew your SIP membership or contact the SIP office.

Utah Meeting Plenary Lectures

As a taster for the Plenary lectures at the Utah meeting, the three speakers have provided articles on their talks.

Dancing with alternate partners: the evolution of virulence factors in insect pathogenic fungi

Michael J. Bidochka[1*] and Nemat Keyhani[2]

[1]Department of Biological Sciences, Brock University, St. Catharines, ON Canada L2S 3A1

[2]Department of Microbiology and Cell Science, University of Florida Gainesville, FL, USA, 32611-0700

Many researchers, as I am, are interested in the virulence factors that allow insect pathogenic fungi such as *Metarhizium anisopliae* and *Beauveria bassiana* to infect insects. The title of this symposium is "The host-pathogen dance: Interactions between insect hosts and their pathogens".

While most research has focused on the mechanisms, at the biochemical and genetic levels, of fungal-insect interaction, I have recently become interested in the evolution of virulence factors in these insect pathogenic fungi. How did these fungi acquire the ability to infect insects? While insects are an important evolutionary force in fungal adaptation to insect pathogenesis I believe that other forces have played a role in fungal evolution as insect pathogens and have "pre-adapted" these fungi to infect insects. Hence the title of my talk "Dancing with alternate partners: The evolution of virulence factors in insect pathogenic fungi". At first, this may appear counter intuitive, however there are examples of pre-adaptation in human pathogens.

Insect pathogenic fungi, such as *M. anisopliae* and *B. bassiana* are considered to be facultative pathogens since they do not require an insect host for propagation. They are somewhat of an enigma since they survive in the soil, maintain virulence and replicate without an insect host, however once isolated from soil they readily infect insects. In fact one of the commonest methods of isolating these fungi is to "bait" the soil with an insect. Virulence factors in these insect pathogenic fungi are not constitutively expressed and there are subsets of virulence-related genes upregulated during the various stages of insect infection so they are well-adapted as insect pathogens. The pathogenicity of these fungi poses the question of how virulence is selected for and maintained in the environment. This question is further complicated by the fact that most isolates of *M. anisopliae var. anisopliae* and *B. bassiana* demonstrate little or no insect host specificity and can infect up to 200 different insect species from various insect orders.

There's a lot of evolutionary hanky-panky going on in the soil where these fungi reside, and I hope to convince some of the audience that just because we've labeled these fungi "insect pathogens" they may be much more than this.

Bt Resistance Management Mambos Nos. 1 and 2

Bruce Tabashnik[1], David Crowder[1], Yves Carrière[1], Aaron Gassmann[2], Luke Masson[3], Alejandra Bravo[4] and Mario Soberón[4]

[1]Department of Entomology, University of Arizona, Tucson AZ, 85750, USA, Ames IA, 50011, USA

[2]Department of Entomology, Iowa State University,

[3]Biotechnology Research Institute, National Research Council of Canada, Montréal, Québec, H4P 2R2, Canada

[4]Instituto de Biotecnología, Universidad Nacional Autónoma de México, Cuernavaca 62250, Morelos, Mexico

To reduce reliance on insecticide sprays, corn and cotton have been genetically engineered to produce *Bacillus thuringiensis* (Bt) proteins that kill some key insect pests. Grown commercially since 1996, transgenic Bt crops covered 46 million hectares worldwide in 2008 (James 2008). First generation Bt corn and cotton each produce a single Bt toxin for control of caterpillar pests. The widespread use of these Bt crops means that the target pests are under intense selection to adapt by evolving resistance.

Bruce Tabashnik works on his balancing act while visiting a Zulu village near Durban, South Africa

The main approach for delaying evolution of pest resistance to Bt crops is the refuge strategy, which requires refuges of host plants without Bt toxins near Bt crops to promote survival of susceptible pests. The refuge strategy arose from mathematical models used to explore tactics for thwarting pest resistance to insecticide sprays, long before Bt crops were even imagined (Georghiou and Taylor 1977, Tabashnik and Croft 1982). The refuge strategy performs brilliantly in computer simulations, but does it work in the real world?

I started working on models of the refuge strategy nearly 30 years ago and was drawn to Bt resistance somewhat by chance (although perhaps inexorably considering my initials). As an assistant professor at the University of Hawaii, my first grant aimed to test modeling predictions by analyzing variation among islands in resistance to pyrethroid insecticides in the diamondback moth, *Plutella xylostella*. In a nutshell, we weren't finding pyrethroid resistance. However, one of the farmers was spraying often with a commercial formulation of Bt toxins rather than pyrethroids. He told us that the Bt sprays weren't killing diamondback moth like they used to. Bioassays of diamondback moth larvae from his farm yielded evidence of the first documented

case of field-evolved resistance to Bt toxins (Tabashnik et al. 1990).

A larva of pink bollworm, *Pectinophora gossypiella*, emerges from a cotton boll (photo by Alex Yelich, University of Arizona)

In 1996, I moved to the University of Arizona and began studying resistance to Bt cotton in pink bollworm, *Pectinophora gossypiella*. Despite rapid selection for resistance in the lab and extensive use of Bt cotton in the field, pink bollworm populations in Arizona have remained susceptible for more than a dozen years to Cry1Ac, the Bt toxin in first generation Bt cotton (Tabashnik et al. 2005, 2006 and unpublished). Global monitoring shows similar sustained susceptibility for most other pests targeted by Bt crops.

A bollworm, *Helicoverpa zea,* caterpillar explores a stem of a cotton plant (photo by Alex Yelich, University of Arizona)

However, three cases of field-evolved resistance to Bt crops have been reported: *Helicoverpa zea* resistance to Bt cotton producing Cry1Ac in the southeastern US, *Spodoptera frugiperda* resistance to Bt corn producing Cry1F in Puerto Rico, and *Busseola fusca* resistance to Bt corn producing Cry1Ab in South Africa (Luttrell et al. 2004, Van Rensburg 2007, Matten et al. 2008, Tabashnik 2008). Even scientists who resisted accepting some of the initial evidence from one case agree that field-evolved resistance to Bt crops is now an established fact (Moar et al. 2008). The pattern of resistance observed in the field corresponds with predictions from the refuge theory, suggesting that refuges do work, especially when resistance is inherited as a recessive trait and refuges are abundant (Tabashnik et al. 2008).

A resistant larva of stem borer, *Busseola fusca*, munches on a stem of Bt corn (photo by Johnnie van den Berg, North-West University, South Africa)

In a new effort to combat pest resistance, some second generation transgenic crops produce two different Bt toxins targeting the same pest. Although this "pyramid" strategy is expected to work best when no cross-resistance occurs between the two toxins, incorporating the potential effects of unexpected cross-resistance in resistance management plans may help to sustain the efficacy of pyramided Bt crops. Other approaches for countering resistance include use of Bt vegetative insecticidal proteins (Vips), RNA interference, and modified Bt toxins genetically engineered to kill pests resistant to native toxins (Baum et al. 2007, Soberón et al. 2007, Pardo-Lopez et al. 2009). With any of these tactics, knowledge of insect resistance to Bt crops can help to minimize risks and enhance benefits for the future.

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Polydnaviruses as symbionts and immunosuppressive pathogens of insects

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The immune system of insects consists of both cellular and humoral elements that innately recognize and eliminate foreign intruders. Reciprocally, pathogens and parasites have evolved a diversity of counterstrategies for circumventing host immune defenses. Understanding the interplay between host defenses and pathogen virulence has been an area of long-standing interest in my laboratory. Our work in this area has also greatly benefitted from collaborative interactions with several other research groups in the US and abroad.

Our studies involve several different insect and pathogen groups, but we have in particular maintained a long-standing interest in the biology of parasitoid wasps and their association with symbiotic polydnaviruses (PDVs). The family Polydnaviridae is currently divided into the ichno- (IV) and bracoviruses (BV) on the basis of their association with parasitoids in the families Ichneumonidae and Braconidae. PDVs are the only viruses with segmented DNA genomes and all have a similar life cycle. PDVs persist as stably integrated proviruses in the genome of associated wasps and replicate in the ovaries of females. When a wasp lays an egg into a host, she injects a quantity of virus that infects hemocytes and other tissues. PDVs do not replicate in the wasp's host but viral gene products suppress the host's immune system, which allows the parasitoid's progeny to develop. Thus, a true mutualism exists between PDVs and wasps as viral transmission depends on parasitoid survival and parasitoid survival depends on immunosuppression of the host by the virus (Figure 1).

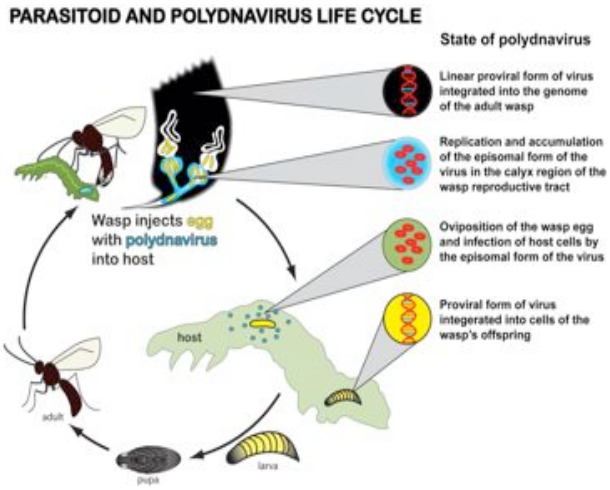

Figure 1 The polydnavirus lifecycle

Recent studies indicate that BVs likely arose from a nudivirus ancestor (Bezier et al., 2009). Subsequently, PDV genomes became segmented with genomic segments individually packaged into nucleocapsids (Figure 2).

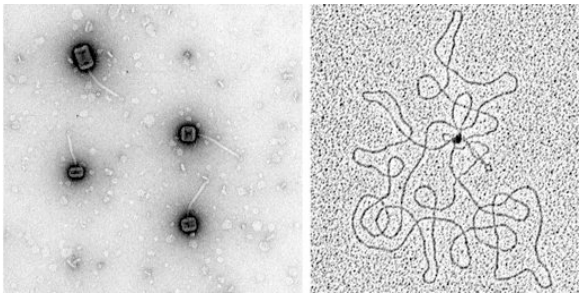

Figure 2 Electron micrograph of negatively stained *Microplitis demolitor* bracovirus (MdBV) nucleocapsids (left) and a circular dsDNA after release by osmotic shock from a nucleocapsid (right)

Different lineages of PDVs also acquired a number of genes that diversified into multimember families (Webb *et al.,* 2006). Our functional experiments focusing on *Microplitis demolitor* bracovirus (MdBV) indicate virions preferentially infect immune cells (hemocytes). We have also identified MdBV gene family members that disable specific cellular and humoral immune defenses including encapsulation and phagocytosis (Pruijssers and Strand, 2007), antimicrobial peptide production (Thoetkiattikul *et al.,* 2005), and melanization (Beck and Strand, 2007; Lu *et al.,* 2008). Interestingly, most immunosuppressive gene products preferentially target pathways regulating specific immune effector molecules rather than the effector molecules themselves.

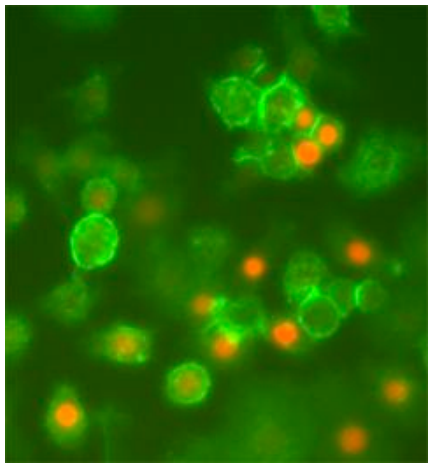

Figure 3 Immunofluorescence micrograph of host insect immune cells expressing two MdBV gene products: Glc1.8 (green) that localizes to the cell surface and MdB1 (red) that localizes to the nucleus

Other studies underway involve understanding how the insect immune system responds to infection by parasitoids and PDVs versus other pathogens (Wertheim *et al.,* 2005; Nakatogawa *et al.,* 2009; Baton *et al.,* 2009). We are also interested in how parasitism impacts other aspects of host physiology including growth, molting and reproduction (Pennacchio and Strand, 2006).

An estimated 30,000 species of wasps carry PDVs. Given that each PDV associated with a given wasp species is genetically unique, PDVs represent a potentially vast repository of gene products with potential for use in insect control or other applications. A second area of study with PDVs that has significant applied implications is in understanding the processes underlying the diversification and host usage patterns of natural enemies.

Indeed, a hallmark of biological control is the use of control agents with restricted host ranges, yet little is known about the traits that actually regulate host usage patterns. Traits that regulate location and recognition of hosts represent one class of factors important in mediating diversification, but of equal importance are traits that regulate survival in hosts. In the case of PDV-carrying species, many of these latter traits reside in the genome of the virus. Thus, the merger of field ecology, systematics, and molecular biology offer significant opportunities for unraveling the relationship between PDV evolution and parasitoid diversification.

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SIP Member News

Award by the Entomological Society of America to Dr Parwinder Grewal

The Recognition Award in Urban Entomology (Sponsored by S.C. Johnson & Son, Inc.) recognizes outstanding extension, research, and teaching contributions in urban entomology, including pests of ornamental plants and turf.

In December 2008, the winner of this Award was announced as Dr. Parwinder S. Grewal, Professor of Entomology at Ohio State University's Ohio Agricultural Research and Development Center. Dr. Grewal is considered a world authority on entomopathogenic nematodes and their application in biological control of turfgrass and horticultural pests.

Recently, Dr. Grewal's laboratory led a series of studies to define parameters associated with nematode application technology. The project joined several disciplines, including physics, engineering, and biology, that significantly extended our knowledge of nematodes in various spray systems.

He is also the leader of the first complete genome sequencing project of an entompathogenic nematode. The sequencing project will lead to numerous new avenues to expand the biocontrol utility and to provide considerable insight into basic pathogen-host relationships.

Dr. Grewal has been elected president of the Society of Nematologists and has published 135 peer-reviewed research papers and edited a book on entomopathogenic nematodes. He has released 34 extension publications, has developed 52 educational programs for the turfgrass industry, and holds six patents.

SIP Division Article

As a new feature, we are keen to commission and receive articles from each of the SIP Divisions. Topics could include opinion pieces, commentaries on regional pest management issues or brief overviews. Our first article is by Jerry Ericsson.

Invertebrate immunity and host-parasite interactions

Jerry Ericsson is Student Representative for Microbial Control Division. He is a PhD candidate in the Department of Biological Sciences, at Simon Fraser University, Burnaby, British Columbia, Canada where his supervisors are Carl Lowenberger (SFU), Jenny Cory (SFU), Judy Myers (UBC) and Mark Goettel (AAFC/SFU).

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When one considers the co-evolutionary history that an entomopathogen or parasite shares with its host, it is reasonable to expect that host immune reactions have played a significant role in defining these interacting traits. In many ways, co-evolution of a host and pathogen is an "arms race" with each having the upper hand at times. Because the immune response occurs early in the encounter, often before symptoms are evident, this intimate relationship is likely to provide clues into the particular mechanisms each pathogen or parasite utilizes to ensure its success.

Although some features are shared, the immune system of invertebrates differs from vertebrates by lacking the adaptive memory component, and an antibody mediated response. This innate immune system comprises a cellular (hemocyte) and humoral component that work together to defend the hemocoel (Gillespie et al., 1997). The immune response begins with recognition of the foreign invader through the binding of host receptors to conserved structures on the microbe called "pathogen associated molecular patterns" (PAMPs). Upon recognition, circulating hemocytes (Fig. 1) phagocytose, encapsulate, or nodulate the foreign structure, while the concurrent production of antimicrobial peptides (AMPs) and enzymes attack the cell membrane or key cellular processes within the pathogen. This two-part system is potent and effective in eliminating most foreign invaders and opportunists.

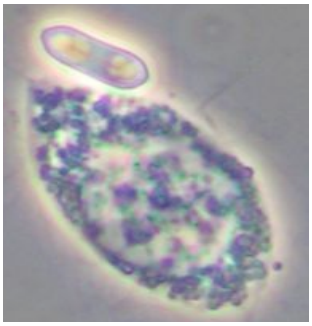

Fig 1. *Metarhizium anisopliae* conidium with hemocyte of *Agriotes obscurus*

To avoid this immune response, pathogens and parasites employ various strategies that only recently have begun to be understood. These strategies can be loosely categorized as evasion, or attack, but a combination of these mechanisms also occurs. The evasion of the immune response happens when pathogens or parasites hide in host tissues that are not accessed by the immune system (intracellular), or when they alter their cell surface such that the host cannot detect their presence. For example, *Wolbachia pipientis* is an obligate, intracellular proteobacterium that resides in the germ cells of infected hosts. *W. pipientis* neither stimulates the synthesis of AMPs in its host, nor prevents their synthesis when other bacteria such as *E. coli* are injected (Bourtzis et al., 2000). This evasive strategy allows *W. pipientis* to grow undetected in the host, while retaining the potency of the immune response to secondary and opportunistic infections.

An attack on the immune system causes an impaired function of the response to all microbes, and occurs when cells participating in an immune response are damaged, or when the effector molecules themselves are destroyed or inhibited in function. For example, some strains of *Bacillus thuringiensis* secrete an AMP-degrading metalloprotease called immune inhibitor A, and this is thought to play a critical role in its pathogenicity (Lovgren et al., 1990).

A combined strategy can be found with *Metarhizium anisopliae* where it can both attack and evade the host immune response. It grows as a hyphal body (Fig. 2) in the hemocoel of susceptible insects (Goettel and Inglis, 1997) and secretes toxic metabolites called destruxins that have immune-modulating and immune-suppressive effects. However, *M. anisopliae* also produces a collagenous extracellular matrix that prevents its recognition by the host immune system (Wang and St Leger, 2007), and thus is able to grow unchecked in the hemocoel.

Fig 2. *Metarhizium anisopliae* hyphal body from hemolymph with hemocyte of *Agriotes obscurus*

These are just a few examples of the mechanisms that enable parasites and pathogens to colonize their invertebrate hosts. By studying invertebrate immunity, we will gain a unique insight into host-parasite interplay, which in turn may have practical applications to the biocontrol of pests, or the prevention of diseases in beneficial insects.

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Industry News

Dow AgroSciences and Syngenta Agree to Cross License Corn Traits

Syngenta and Dow AgroSciences have announced an agreement to cross license their respective corn traits for commercialization within their branded seed businesses. The agreement will allow both companies to maximize the value of their technologies and to bring greater choice and flexibility to growers.

Under the terms of the agreement, Syngenta will receive global non-exclusive licenses, with stacking rights, to Dow AgroSciences' Herculex® I Insect Protection for broad lepidopteran control and to Herculex® RW for corn rootworm control.

Additionally, Dow AgroSciences will receive global non-exclusive licenses with stacking rights to Syngenta's Agrisure® GT trait for glyphosate tolerance, and to its insect control traits Agrisure® CB/LL for corn borer and Agrisure® RW for corn rootworm. The licenses also include access to Syngenta's Agrisure Viptera™ trait for broad lepidoptera control and to a second generation trait for corn rootworm control.

Dow AgroSciences Receives Approval for New Technology to Control Cotton Pests in Brazil

Technology incorporates naturally occurring soil micro-organism proteins to protect cotton plantations

Dow AgroSciences LLC has received regulatory approval from the Brazilian National Technical Commission on Biosafety (CTNBio), for its WideStrike™ Insect Protection technology in cotton in Brazil. WideStrike, currently marketed in the United States, provides season-long, whole-plant protection from insect feeding cotton pests.

The WideStrike technology uses two insect resistant traits that effectively control important cotton pests especially *Spodoptera frugiperda, Heliothis virescens*, *Pectinophora gossypiella* and *Alabama argillacea*.

Cottonseed containing this technology has been planted since 2004 in the United States where the oil and meal produced from WideStrike cottonseed has been approved for use in human food and animal feed. These products have also been approved for use in human food and animal feed in Canada and in Japan, as well as for human consumption in Mexico, South Korea, and Australia.

In December 2008, CTNBio granted approval for HERCULEX® I Insect Protection technology and commercialization of the HERCULEX I hybrid corn seeds, which also produces a Bt protein to protect the plant, has already been approved by the Brazilian Ministry of Agriculture.

Contrast between WideStrike and non-WideStrike cotton plots

Contact the Newsletter if you wish to submit articles or features on production, formulation, field testing, regulatory approval or marketing of microbial control agents.

Paresh Shah

Obituary

Claire Vidal, 1969 - 2009

Claire Vidal, scientist at the Center of Population Biology and Control (UMR CBGP) in Montpellier, France, passed away on Tuesday, March 17th at the age of 40, after a three year courageous battle with cancer.

Claire was born on February 19, 1969. She obtained her Engineering in Agronomy degree from the "Ecole Nationale Ingénieurs Travaux Agricoles de Bordeaux" in 1992, a Master's Degree in Parasitology in 1993 and a Ph.D in Population Biology & Ecology in 1997 at the University of Montpellier II, France.

Her research speciality was ecopathology of entomopathogenic fungi and microbial control of insect pests. Since 2004, she was employed at the French overseas Institute for Research and Development where she was carrying out a research program on the dynamics of pathosystems (whiteflies-entomopathogenic fungi-tomato greenhouses) for improving biologically-based crop protection strategies in Mediterranean and tropical areas. Passionate about her job, she continued to work while facing her battle with cancer with exemplary courage.

Claire was internationally recognized and her death will create a lack in her discipline and in the scientific community. The rigor of her analysis, her interest in an interdisciplinary and systemic approach, her sense of responsibility, together with her energy, her humour and charisma, earned her great respect and deep friendship with all who had the privilege and pleasure to work with her within the UMR CBGP or in many French or foreign laboratories. Her premature departure will leave a particularly large gap in the heart of her 9 year old daughter, Ambre.

Jacques Fargues

Montpellier, France

Announcements and News

The Annual Meeting SIP for 2011 will be held in Halifax, Nova Scotia, Canada

The SIP Meetings Committee is pleased to announce that Council has approved its recommendation to hold the 2011 SIP Meeting in Halifax, Nova Scotia, Canada.

Halifax, located on the east coast, is a very attractive venue offering a variety of extra-curricular activities before and after the meeting.

The proposed program committee is made up of some of our most talented and dedicated members setting the stage for a diverse and intellectually memorable meeting.

The meeting will be held at Saint Mary's University (www.smu.ca) at the south end of Halifax's peninsula in a picturesque area.

Several types of reasonably priced rooms will be available on campus. Three residence buildings house up to 600 people during the summer and there are several choices for off campus accommodations. The meeting rooms are equipped with computers and projectors and an audio-visual technician will be available to assist with the technology and to address any problems.

Smaller meeting rooms (for workshops and business meetings) are equipped with whiteboards, overhead projectors and screens.

Reasonably priced lunches and dinners will be provided on campus. There are also many restaurants within walking distance of the University.

Tentative dates are 7 – 12 August, 2011.

Please let me know right away if the proposed dates conflict with other meetings that may be of interest to SIP Members.

Lerry Lacey

SIP Meetings Committee

Internet Database on Diagnosis of Arthropod Diseases from the Julius Kühn Institut

Since 18 March 2009, a database on the diagnosis of diseases of insects and other arthropods is available in German and English versions at: http://arthropodenkrankheiten.jki.bund.de.

It is based on 55 years of diagnostic investigations of living, diseased, and dead arthropods, particularly insects, at the Institute for Biological Control, Darmstadt, Germany. The studies have been conducted primarily by Dr. A.M. HUGER and, since 1991, by Dr. R.G. KLEESPIES as well as by other scientists at the Institute.

The database comprises results of 1951 accessions with several thousands of diagnosed specimens from 1953 to 2008. About 450 arthropod species of the following orders were investigated (in alphabetical order):

Acari, Anoplura, Arachnida, Auchenorrhyncha, Blattoptera, Coleoptera, Dermaptera, Diptera, Heteroptera, Hymenoptera, Isoptera, Lepidoptera, Mantodea, Neuroptera, Phasmatodea, Psocoptera, Raphidioptera, Saltatoria (Orthoptera), Scorpionida, Sternorrhyncha, and Thysanoptera.

The diagnosed pathogens belong to six groups: viruses, bacteria (including rickettsiae), fungi, microsporidia (recently assigned to fungi), protists, and nematodes.

Geographical locations (countries, cities) as well as accession number and year are also shown. The names of orders, genera, and species of the listed arthropods and pathogens are up to date, but older names and synonyms may also be mentioned.

In contrast to the recent journal publication (KLEESPIES, R.G., A.M. HUGER, G. ZIMMERMANN, 2008: Diseases of insects and other arthropods: results of diagnostic research over 55 years. Biocontrol Science and Technology 18, 439-484), the electronic database allows selective search for genera and species of arthropods as well as for pathogens.

Furthermore, countries and cities can be checked and combinations between different items are possible. The aim of this database is to advise interested scientists and experts of entomology, microbiology, biological and integrated control, but also to help insect breeders on the occurrence of pathogens and diseases, including nematodes, of pest and beneficial arthropods. The database will be updated regularly.

R.G. KLEESPIES, A.M. HUGER & G. ZIMMERMANN

Julius Kühn-Institute, Institute for Biological Control, Darmstadt, Germany