SIP
SOCIETY FOR INVERTEBRATE PATHOLOGY

Tours 2016

49th Annual Meeting
of the
Society for Invertebrate Pathology

International Congress
on Invertebrate Pathology and Microbial Control

Scientific highlights from last year

2015- 2016 Virus Division Highlight # 1
Zika Virus Re-Emergence > Renewed Interest in Vector Biology

J Glob Infect Dis. 2016 Jan-Mar; 8(1): 3–15. PMCID: PMC4785754
doi: 10.4103/0974-777X.176140

The Emergence of Zika Virus as a Global Health Security Threat: A Review and a Consensus Statement of the INDUSEM Joint working Group (JWG)

Veronica Sikka, Vijay Kumar Chattu,[1] Raaj K Popli,[2] Sagar C Galwankar,[3] Dhanashree Kelkar,[3] Stanley G Sawicki,[4] Stanislaw P Stawicki,[5] and Thomas J Papadimos[6]

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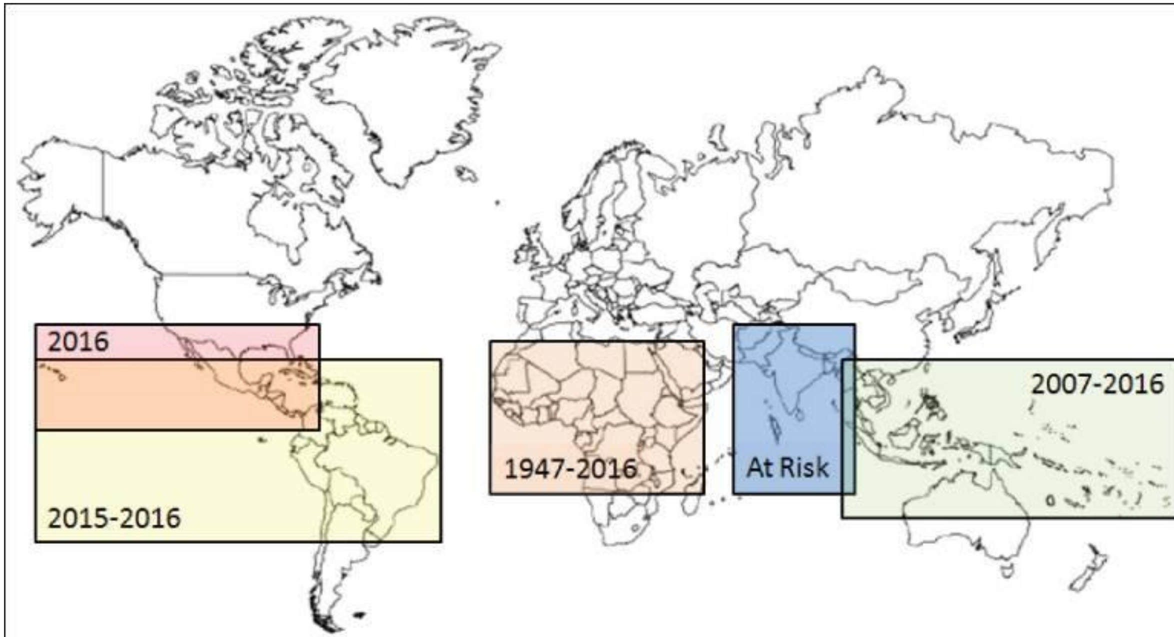


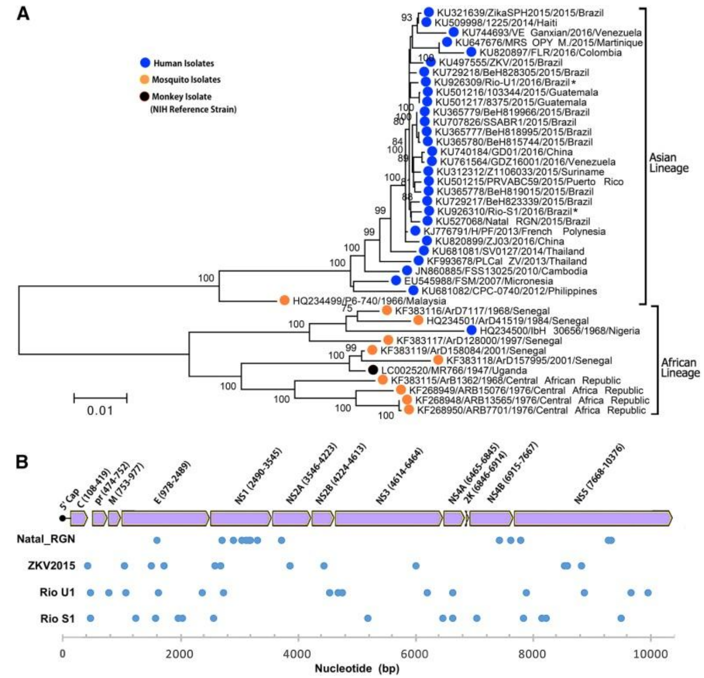
Global Spread of Zika Virus – Geographic zone-specific time ranges of known incidences are shown color-coded according to the year of the earliest reported case (locally-acquired cases or viral isolation). Other locations / countries reported presumably imported cases of ZIKV (including Japan; Illinois, United States; Denmark, European Union)

From Mosquitos to Humans: Genetic Evolution of Zika Virus

Lulan Wang[10], Stephanie G. Valderramos[10], Aiping Wu, Songying Ouyang, Chunfeng Li, Patricia Brasil, Myrna Bonaldo, Thomas Coates, Karin Nielsen-Saines, Taijiao Jiang, Roghiyh Aliyari, Genhong Cheng

[10] Co-first author

DOI: http://dx.doi.org/10.1016/j.chom.2016.04.006 | CrossMark



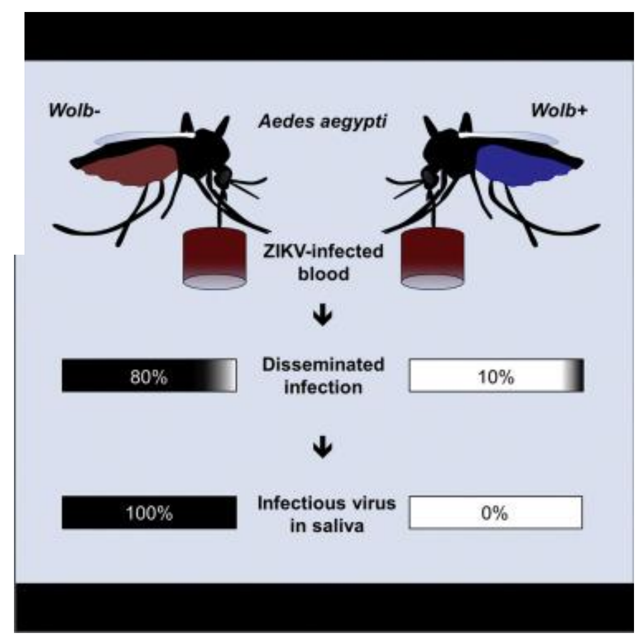
Wolbachia Blocks Currently Circulating Zika Virus Isolates in Brazilian *Aedes aegypti* Mosquitoes

Heverton Leandro Carneiro Dutra, Marcele Neves Rocha, Fernando Braga Stehling Dias, Simone Brutman Mansur, Eric Pearce Caragata, Luciano Andrade Moreira

Open Access

DOI: http://dx.doi.org/10.1016/j.chom.2016.04.021 | CrossMark

Open access funded by Bill & Melinda Gates Foundation



2015- 2016 Virus Division Highlight # 2
Baculovirus isolated from an insect of medical interest

The complete genome of a baculovirus isolated from an insect of medical interest: *Lonomia obliqua* (Lepidoptera: Saturniidae)

C. W. Aragão-Silva, M. S. Andrade, D. M. P. Ardisson-Araújo, J. E. A. Fernandes,
F. S. Morgado, S. N. Báo1, R. H. P. Moraes, J. L. C. Wolff, F. L. Melo& B. M. Ribeiro

Science Reports 6:23127 | DOI: 10.1038/srep23127 1

***Lonomia obliqua* (Lepidoptera: Saturniidae) is a species of medical importance due to the severity of reactions caused by accidental contact with the caterpillar bristles.**

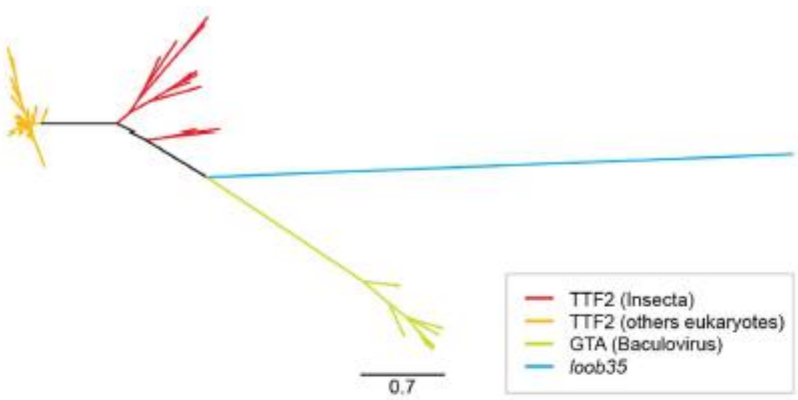
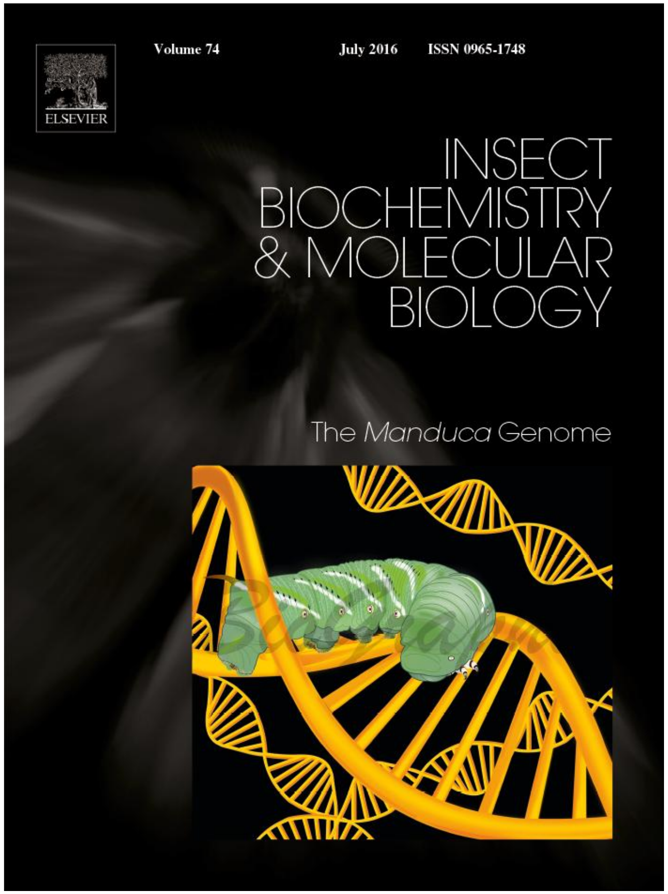


Figure 5. Phylogeny of GTAs and TTF2 genes. Unrooted maximum likelihood phylogeny of the data set containing genes that correspond to TTF2 from Insecta (red), TTF2 from other eukaryote (orange), GTA from group I *Alphabaculovirus* (green), and *loob035* (blue).

2015- 2016 Virus Division Highlight # 3
Manduca sexta Draft Genome – Tool for Host-Pathogen Studies

Multifaceted Biological Insights from a Draft Genome Sequence of the Tobacco Hornworm Moth, *Manduca sexta*

Michael R. Kanost, Garry W. Blissard et al.
Insect Biochemistry and Molecular Biology; Accepted 7/13/2016



2015-2016 Diseases of Beneficial Invertebrates (DBI) Division Highlight 1

The opportunistic marine pathogen *Vibrio parahaemolyticus* becomes virulent by acquiring a plasmid that expresses a deadly toxin

Lee *et al*., 2016
PNAS

www.pnas.org/cgi/doi/10.1073/pnas.1503129112

The opportunistic marine pathogen *Vibrio parahaemolyticus* becomes virulent by acquiring a plasmid that expresses a deadly toxin – Lee *et al*., 2016, PNAS

- Emergent disease in penaeid shrimp - Acute Hepatopancreatic Necrosis Disease (AHPND)
- Responsible for large losses in shrimp farming industry
- This paper describes that an AHPND-causing strain of *V. parahaemolyticus* contains a 70-kbp plasmid (pVa1)
- Ability to cause disease is the deletion of the plasmid encoding homologs of the *Photorhabdus* insect-related (Pir) toxins PirA and PirB
- $PirAB^{vp}$ toxin leads to destruction of shrimp hepatopancreas
- Crystal structure determined, structural topology found to be similar to *Bacillus* Cry insecticidal toxin-like protein, low sequence identity
- Gene organisation of pVA1 suggests $PirAB^{vp}$ may be lost or acquired by horizontal gene transfer

2015-2016 Diseases of Beneficial Invertebrates (DBI) Division Highlight 2

First Detection of the Larval Chalkbrood Disease Pathogen *Ascosphaera apis* (Ascomycota: Eurotiomycetes: Ascosphaerales) in Adult Bumble Bees

Maxfield-Taylor *et al*. 2015
PLOS ONE

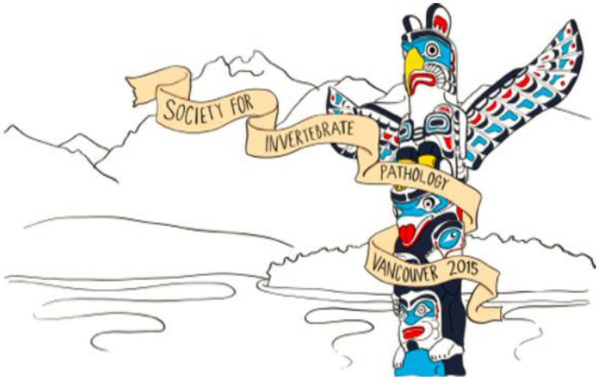
DOI:10.1371/journal.pone.0124868

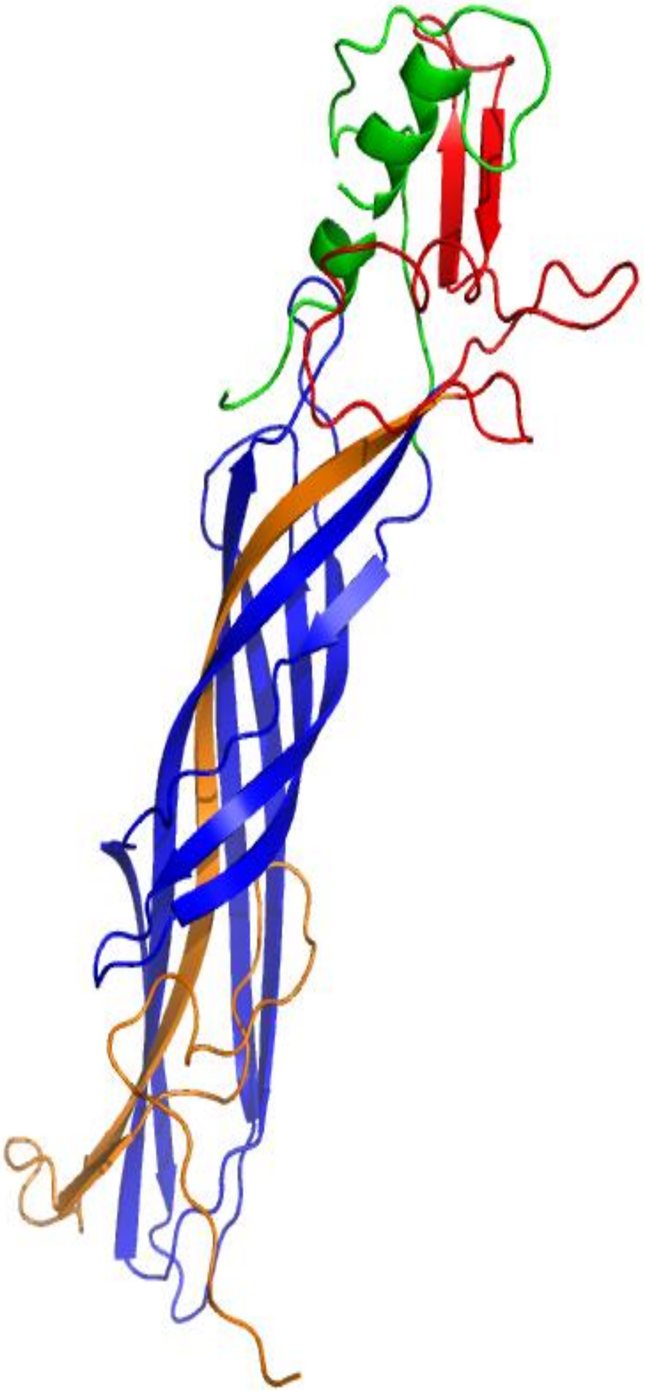
First Detection of the Larval Chalkbrood Disease Pathogen *Ascosphaera apis* (Ascomycota: Eurotiomycetes: Ascosphaerales) in Adult Bumble Bees – Maxfield-Taylor *et al*., 2015, PLOS ONE

- This paper reports the first-ever detection of the fungus in adult bumble bees which were raised in captivity
- Wild queens of Bombus griseocollis, B. nevadensis and B. vosnesenskii were collected and maintained for establishment of nests
- Queens that died during rearing or that did not lay eggs within one month of capture were dissected, and tissues were examined microscopically for the presence of pathogens
- Filamentous fungi was identified as *Ascosphaera apis* (Maasen ex Claussen) Olive and Spiltoir, a species that has been reported from larvae
- The identity of the fungus was confirmed using molecular markers and phylogenetic analysis
- Discovery of *A. apis* in adult bumble bees highlights potential risks to native bees via pathogen spillover from infected bees and infected pollen.

SIP Bacteria Division Workshop:
"Regulatory Considerations for the Commercialization of New Insecticidal Proteins"

Published in combination with papers from the 2014 SIP symposium: "Structure and Function of Novel Insecticidal Toxins", *in a Journal of Invertebrate Pathology Special Issue, 2016*



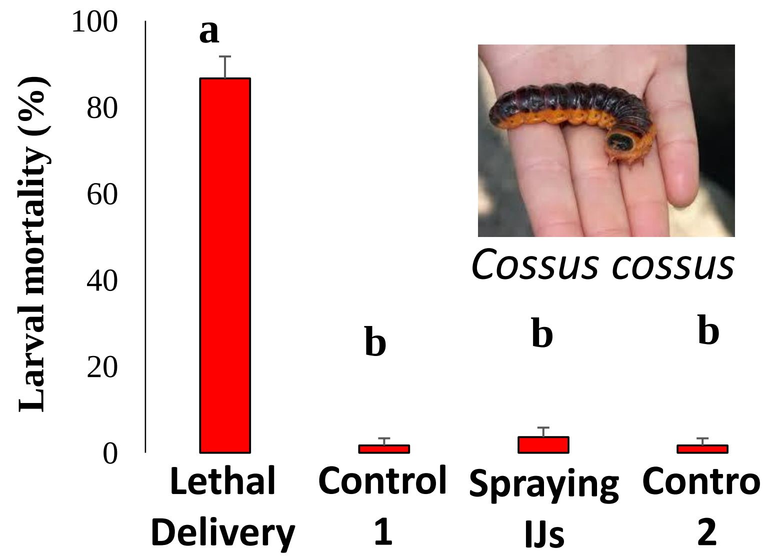


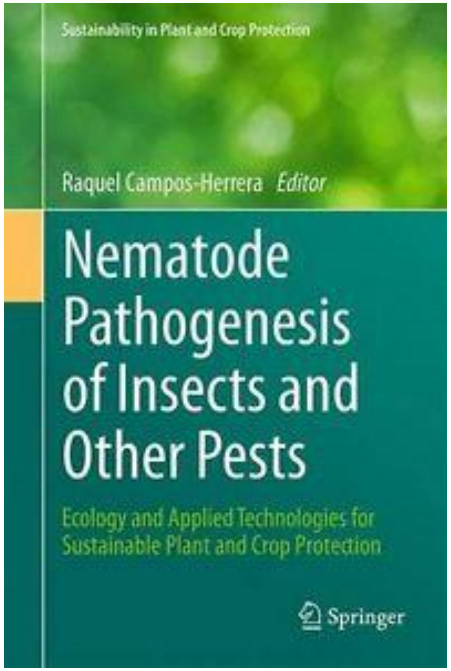
A novel approach to biocontrol: Release of live insect hosts pre-infected with entomopathogenic nematodes

Gumus, A., Karagoz, M., Shapiro-Ilan, D. I and **Hazir, S. (2015). Journal of Invertebrate Pathology**, 130: 56-60.

The pre-infected insects carriers, while still alive, enter hard-to-reach locations such as inside logs and thereby introduce the nematodes to the target pest.

Releasing live insect hosts pre-infected with EPNs (=**"Lethal Delivery")** against insect pests living in cryptic habitats was discovered to be superior to standard application methods (spraying IJs).





Nematode Pathogenesis of Insects and Other Pests

R. Campos-Herrera (Ed), 2015

Series: Sustainability in Plant and Crop Protection (A. Ciancio, Ed.) Springer
ISBN 978-3-319-18265-0, DOI 10.1007/978-3-319-18266-7

- A highly novel compendium in applied **Entomopathogenic Nematology** in 21 chapters
- **Basic and applied state-or-the-art research**: new technologies and molecular approaches in a global perspective
- A total of **44 world renown contributors** from **17 countries** provided their expert vision in each topic

PART I: Biological and environmental factors affecting entomopathogenic nematodes as biological control agents (6 chapters)

PART II: Advances on entomopathogenic nematodes production and release (4 chapters)

PART III: entomopathogenic nematode exploitation: case-studies in crop protection in different crops and countries (11 chapters, NY-USA, Fl-USA, NJ-USA, Venezuela, Cuba, Spain, Italy, Czech Republic, Iran, South Africa, New Zealand)

2015-2016 Microsporidia Division Highlight

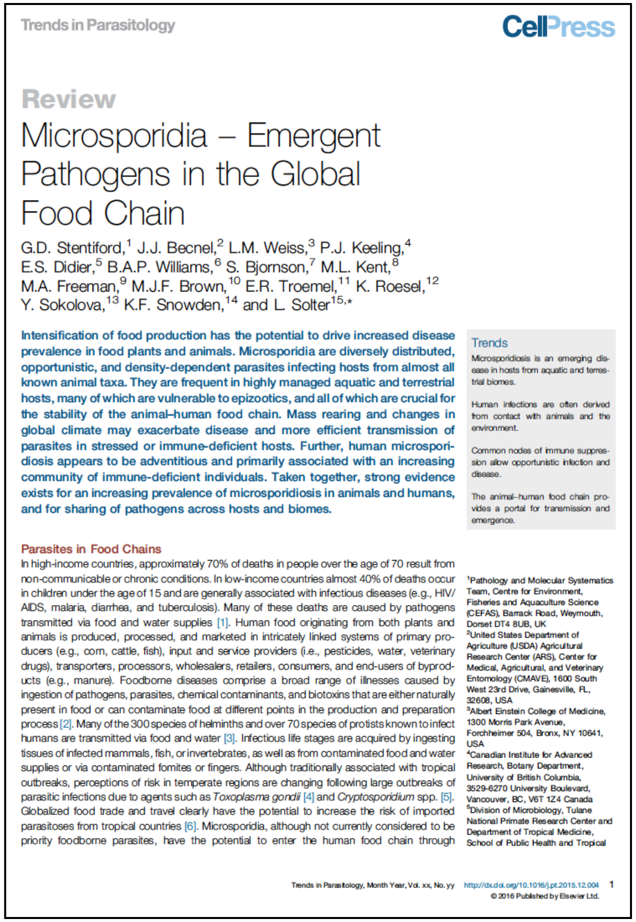
Microsporidia – Emergent pathogens in the global food chain

G.D. Stentiford, J.J. Becnel, L.M. Weiss, P.J. Keeling, E.S. Didier, B.A.P. Williams, S. Bjornson, M.L. Kent, M.A. Freeman, M.J.F. Brown, E.R. Troemel, K. Roesel, Y. Sokolova, K.F. Snowden, L. Solter

Trends in Parasitology

2016 Apr 32(4): 336-48.

Intensification of food production may increase disease prevalence in plants & animals used as food



Trends in Parasitology

CellPress

Review

Microsporidia – Emergent Pathogens in the Global Food Chain

G.D. Stentiford,[1] J.J. Becnel,[2] L.M. Weiss,[3] P.J. Keeling,[4] E.S. Didier,[5] B.A.P. Williams,[6] S. Bjornson,[7] M.L. Kent,[8] M.A. Freeman,[9] M.J.F. Brown,[10] E.R. Troemel,[11] K. Roesel,[12] Y. Sokolova,[13] K.F. Snowden,[14] and L. Solter[15,*]

Intensification of food production has the potential to drive increased disease prevalence in food plants and animals. Microsporidia are diversely distributed, opportunistic, and density-dependent parasites infecting hosts from almost all known animal taxa. They are frequent in highly managed aquatic and terrestrial hosts, many of which are vulnerable to epizootics, and all of which are crucial for the stability of the animal–human food chain. Mass rearing and changes in global climate may exacerbate disease and more efficient transmission of parasites in stressed or immune-deficient hosts. Further, human microsporidiosis appears to be adventitious and primarily associated with an increasing community of immune-deficient individuals. Taken together, strong evidence exists for an increasing prevalence of microsporidiosis in animals and humans, and for sharing of pathogens across hosts and biomes.

Trends

Microsporidiosis is an emerging disease in hosts from aquatic and terrestrial biomes.

Human infections are often derived from contact with animals and the environment.

Common nodes of immune suppression allow opportunistic infection and disease.

The animal–human food chain provides a portal for transmission and emergence.

Parasites in Food Chains

In high-income countries, approximately 70% of deaths in people over the age of 70 result from non-communicable or chronic conditions. In low-income countries almost 40% of deaths occur in children under the age of 15 and are generally associated with infectious diseases (e.g., HIV/AIDS, malaria, diarrhea, and tuberculosis). Many of these deaths are caused by pathogens transmitted via food and water supplies [1]. Human food originating from both plants and animals is produced, processed, and marketed in intricately linked systems of primary producers (e.g., corn, cattle, fish), input and service providers (i.e., pesticides, water, veterinary drugs), transporters, processors, wholesalers, retailers, consumers, and end-users of byproducts (e.g., manure). Foodborne diseases comprise a broad range of illnesses caused by ingestion of pathogens, parasites, chemical contaminants, and biotoxins that are either naturally present in food or can contaminate food at different points in the production and preparation process [2]. Many of the 300 species of helminths and over 70 species of protists known to infect humans are transmitted via food and water [3]. Infectious life stages are acquired by ingesting tissues of infected mammals, fish, or invertebrates, as well as from contaminated food and water supplies or via contaminated fomites or fingers. Although traditionally associated with tropical outbreaks, perceptions of risk in temperate regions are changing following large outbreaks of parasitic infections due to agents such as *Toxoplasma gondii* [4] and *Cryptosporidium* spp. [5]. Globalized food trade and travel clearly have the potential to increase the risk of imported parasitoses from tropical countries [6]. Microsporidia, although not currently considered to be priority foodborne parasites, have the potential to enter the human food chain through

[1]Pathology and Molecular Systematics Team, Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Barrack Road, Weymouth, Dorset DT4 8UB, UK
[2]United States Department of Agriculture (USDA) Agricultural Research Center (ARS), Center for Medical, Agricultural, and Veterinary Entomology (CMAVE), 1600 South West 23rd Drive, Gainesville, FL, 32608, USA
[3]Albert Einstein College of Medicine, 1300 Morris Park Avenue, Forchheimer 504, Bronx, NY 10641, USA
[4]Canadian Institute for Advanced Research, Botany Department, University of British Columbia, 3529-6270 University Boulevard, Vancouver, BC, V6T 1Z4 Canada
[5]Division of Microbiology, Tulane National Primate Research Center and Department of Tropical Medicine, School of Public Health and Tropical

Trends in Parasitology, Month Year, Vol. xx, No. yy http://dx.doi.org/10.1016/j.pt.2015.12.004 1

- Mass rearing & global climate changes may exacerbate disease & enhance pathogen transmission
- Human microsporidiosis seems adventitious; associated with an increasing community of immune-deficient individuals

Overall, strong evidence exists for:

- An increase in the prevalence of microsporidiosis in animals & humans
- Pathogen sharing across hosts & biomes

Resulting publication of the 2015 OECD-sponsored symposium (SIP Vancouver)

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BETTER POLICIES FOR BETTER LIVES

Microsporidia in the Animal to Human Food Chain: An International Symposium to Address Chronic Epizootic Disease

SOCIETY FOR INVERTEBRATE PATHOLOGY
SIP

Sponsored by the Organisation for Economic Co-operation and Development- Co-operative Research Programme (OECD-CRP) and the Society for Invertebrate Pathology

Organizers: G.D. Stentiford, J.J. Becnel. L.M. Weiss, L. Solter

16 speaker presentations & discussion on microsporidia as emerging pathogens in:

- Humans
- Farmed animals & terrestrial wildlife
- Companion animals
- Wild & cultured fish
- Aquatic & terrestrial arthropods

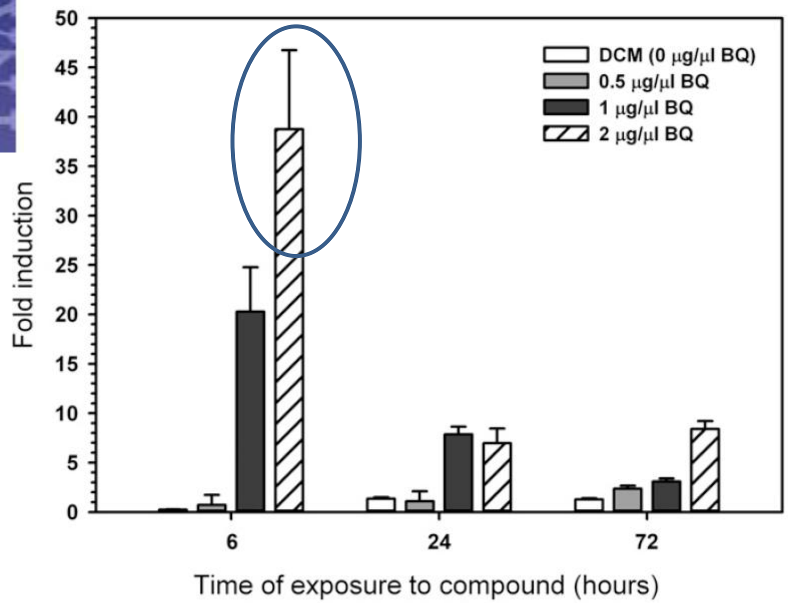
Fungi division Highlights:
Host-fungus co-evolution in two systems
Unravelling mechanisms for defence and manipulation.

<u>Generalist fungal entomopathogen:</u>
Host *Tribolium castaneum* defends itself with anti-fungal benzoquinones, *Beauveria bassiana* detoxifies by benzoquinone reductase as countermeasure (Pedrini et al. 2015).

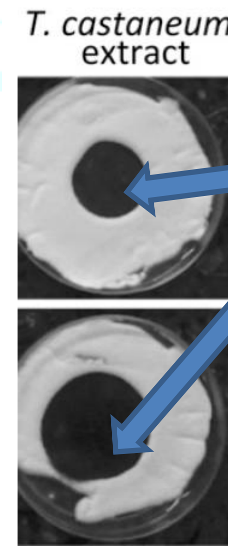
<u>Specialist fungal entomopathogen:</u>
Unravelling fungal gene toolbox of *Ophiocordyceps unilateralis* during manipulative biting behaviour during death of host ant *Camponotus castaneus* (de Bekker et al. 2015).

Tenebrionid secretions and a fungal benzoquinone oxidoreductase form competing components of an arms race between a host and pathogen

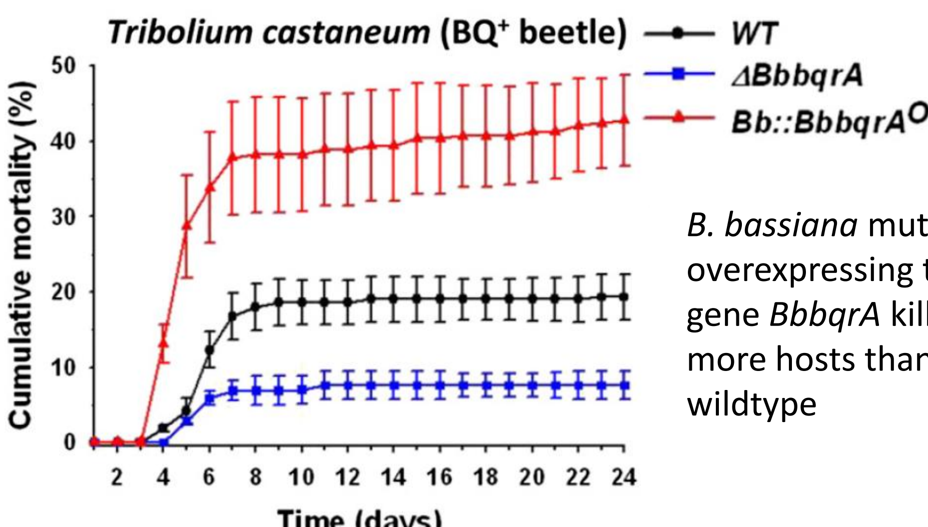
Nicolás Pedrini[a,1,2], Almudena Ortiz-Urquiza[b,1], Carla Huarte-Bonnet[a], Yanhua Fan[b,c], M. Patricia Juárez[a], and Nemat O. Keyhani[b,2]



The gene *BbbqrA* of *B. bassiana* is upregulated 40x when exposed to benzoquinones for 6 hours.



Benzoquinones from host inhibit *B. bassiana* growth; more so if *BbbqrA* is knocked out.



B. bassiana mutant overexpressing the gene *BbbqrA* kills more hosts than wildtype

- Host has evolved anti-fungal defence compounds.
- *B. bassiana* produces enzyme to detoxify the compound.
- Pathogen is currently behind in the arms race in this system

de Bekker *et al. BMC Genomics* (2015) 16:620
DOI 10.1186/s12864-015-1812-x

BMC Genomics

RESEARCH ARTICLE **Open Access**

Gene expression during zombie ant biting behavior reflects the complexity underlying fungal parasitic behavioral manipulation

Charissa de Bekker[1,2*], Robin A. Ohm[3], Raquel G. Loreto[2,4], Aswathy Sebastian[5], Istvan Albert[5,6], Martha Merrow[1], Andreas Brachmann[7] and David P. Hughes[2*]

Which fungal and host genes are expressed during manipulation? Mixed transcriptome

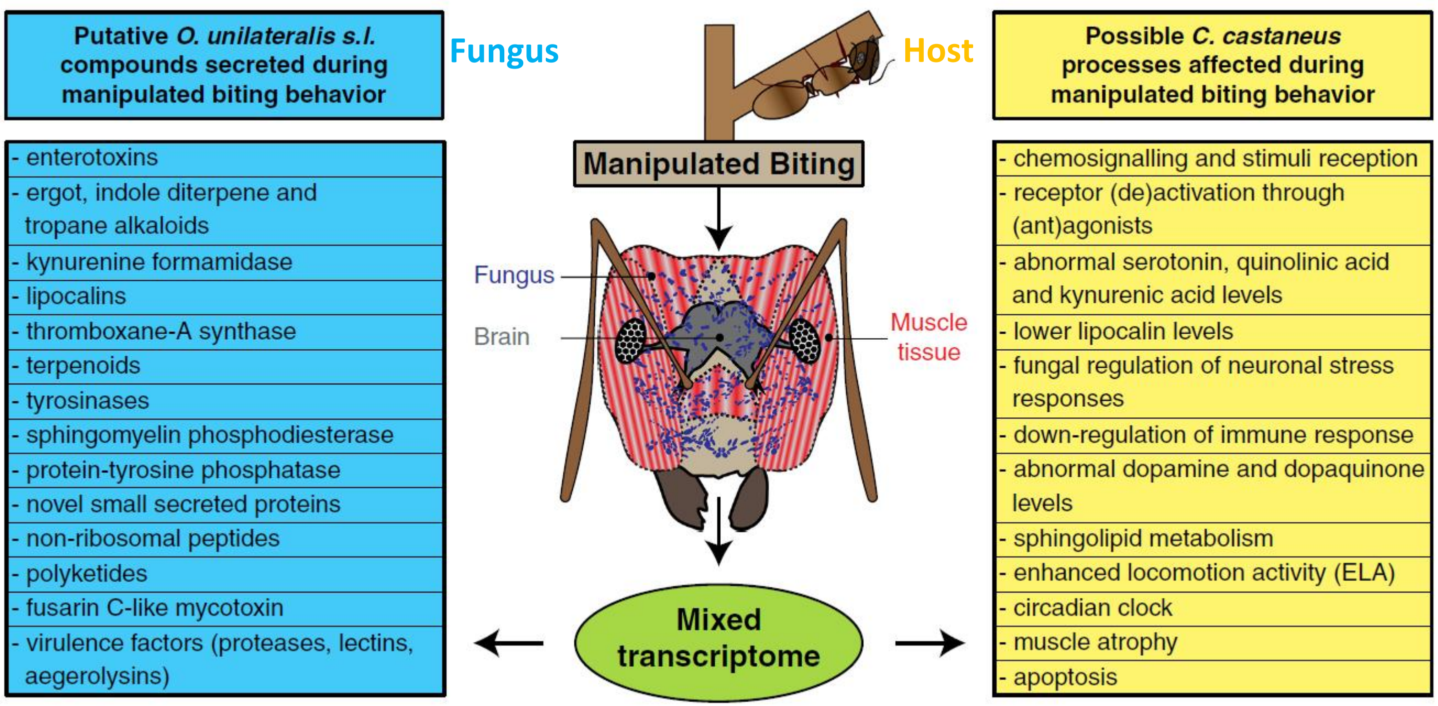


Fig. 4 Infographic summarizing the putatively secreted *O. unilateralis s.l.* compounds and possible *C. castaneus* processes found in this study that are seemingly involved in manipulation

- Fungal genes for pathogenesis but also of unknown function.
- Host genes regulating apoptosis, movement and behavioural responses.
- Fungus takes over control of host.

Highlights in Microbial Control 2015-2016

The microbial control division is concerned with the implementation of insect pathology for control.

- The Nagoya Protocol ratified by 50 countries. Fair and equitable sharing among countries of benefits arising from utilization of genetic resources. Signed by all EU Member States but not the USA.

- EU developed criteria for assessing new active substances as Low Risk – will make a fast track process for product registration of 120 days instead of 1-1.5 years.

Highlights in Microbial Control 2015-2016

- FAO preparing guidance for micro-organism, botanicals and semio-chemicals – to harmonise and develop proportional and appropriate regulations.

- Biopesticide market figures have been forecast upwards from a current CAGR of around 15%: according to some sources, the biopesticides market is projected to reach USD 6.6 Billion by 2020 and is expected to grow at a CAGR of 18.8% from 2015 to 2020.

Highlights in Microbial Control 2015-2016

As microbial control division is concerned with the implementation of insect pathology for control, want to highlight the review-

- **Lacey et al., JIP 2015, Insect pathogens as biological control agents- back to the future**

Also a new "Burges and Hussey" book, edited by Lerry Lacey, out soon


Journal of Invertebrate Pathology 132 (2015) 1–41

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Insect pathogens as biological control agents: Back to the future

L.A. Lacey [a,*], D. Grzywacz [b], D.I. Shapiro-Ilan [c], R. Frutos [d], M. Brownbridge [e], M.S. Goettel [f]

[a] IP Consulting International, Yakima, WA, USA
[b] Agriculture Health and Environment Department, Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent ME4 4TB, UK
[c] U.S. Department of Agriculture, Agricultural Research Service, 21 Dunbar Rd., Byron, GA 31008, USA
[d] University of Montpellier 2, UMR 5236 Centre d'Etudes des agents Pathogènes et Biotechnologies pour la Santé (CPBS), UM1-UM2-CNRS, 1919 Route de Mendes, Montpellier, France
[e] Vineland Research and Innovation Centre, 4890 Victoria Avenue North, Box 4000, Vineland Station, Ontario L0R 2E0, Canada
[f] Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, Alberta, Canada[1]

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Bacillus thuringiensis
Bt-crops

ABSTRACT

The development and use of entomopathogens as classical, conservation and augmentative biological control agents have included a number of successes and some setbacks in the past 15 years. In this forum paper we present current information on development, use and future directions of insect-specific viruses, bacteria, fungi and nematodes as components of integrated pest management strategies for con-trol of arth…

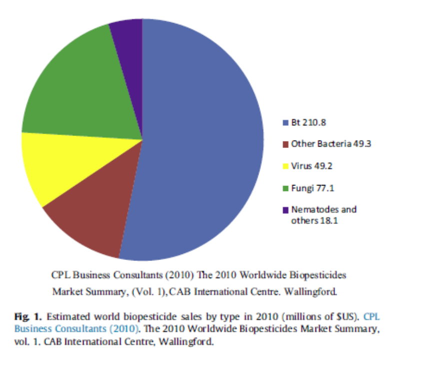

Fig. 1. Estimated world biopesticide sales by type in 2010 (millions of $US). CPL Business Consultants (2010). The 2010 Worldwide Biopesticides Market Summary, vol. 1. CAB International Centre, Wallingford.