

Impact case study (REF3b)

Institution: University College London / Birkbeck College
Unit of Assessment: 5 - Biological Sciences
Title of case study: Fungus research: impacts on pest control, heritage conservation and public awareness of science
1. Summary of the impact <p>Research over the last 20 years by Jane Nicklin (née Faull) and her research group has established expertise in fungi, which has led to impacts in three areas: impacts on the licensing of commercial products for the control of insect pests which affect food crops, which have led to a new product being licensed in the US to the benefit of vine growers; impacts on heritage conservation, where the work has benefitted English Heritage, the National Trust and many other conservation groups; and impacts on public awareness and media engagement with science, in particular through her work with Channel 4's <i>How Clean is your House?</i> in 2009.</p>
2. Underpinning research <p>The research which underpins these impacts was undertaken by Jane Nicklin at Birkbeck, University of London. Her work has centred on the study of fungal biochemistry, physiology and molecular biology. This work has covered two main areas: (i) the use of fungi as biological control agents against insect pests, invasive weeds and nematodes; and (ii) the presence and hazards of fungal species in collections of historical artefacts, and resulting issues with indoor air quality.</p> <p>Crop plant losses due to pests, weeds and parasitic organisms remain one of the greatest threats to food security worldwide and remain stubbornly at over 30% despite the use of pesticides. The increasing use of monoculture and consequent decrease in crop diversity has exacerbated these problems; the bulk of our staple foods is provided by just fourteen species. Pesticide resistance is also an increasing problem. The use of micro-organisms as biological pesticides, in which the natural interactions between predator, prey and parasite host are used to control populations of unwanted organisms, is a key aspect of integrated pest management. Research in Nicklin's group over many years has focused on the development of fungi as biological control agents, exploiting the natural ability of many of these organisms to kill different types of parasite and pest. Work in the laboratory has focused at different times on fungi with activity against plant pathogens, insects and weeds, and now also nematodes.</p> <p>Nicklin and her co-workers studied the interactions of <i>Trichoderma</i> strains with plant pathogens and identified mechanisms of action that are vital to the interaction processes. These interactions can be mediated by secreted antimicrobial compounds, including toxins and enzymes, or as a competitor to pathogenic fungi. Preparations of this fungus were designed to optimise its growth and persistence on the target plant species, and its antagonism against the pathogens concerned [1, 2].</p> <p>Insects such as the white fly cause considerable economic losses, not just due to the loss of crop yield, but also as they can act as transmission agents for viral diseases of crop plants. Nicklin and her Ph.D. student Pasco Avery worked with collaborators at the Royal Botanic Gardens, Kew, to develop preparations of the fungus <i>Isaria fumosorosea</i> to control infestations of white fly (<i>Trialeurodes vaporariorum</i>) in laboratory and pot trials [3]. Avery and his co-workers developed a novel bioassay to determine the horizontal transmission efficiency of Trinidadian strains of the fungus against simulated leaf infestations of <i>Trialeurodes vaporariorum</i> under optimum conditions. They showed that the fungal spores could colonize and destroy the white fly efficiently, and proved that colonization increased with the length of the light period (photophase) and decreased with distance from the target insects, suggesting that preparations of this fungus could usefully be commercialised as biopesticides [4]. They also suggested that this assay design would be useful in assessing the transmission efficiency of other fungi for commercial development as biopesticides.</p>

3. References to the research

- [1] Faull JL, Graeme-Cook K, Pilkington B. Production of an isonitrile antibiotic by an UV-induced mutant of *Trichoderma harzianum*. *Phytochemistry*. 1994 Jul;36(5):1273-6. [http://dx.doi.org/10.1016/S0031-9422\(00\)89649-1](http://dx.doi.org/10.1016/S0031-9422(00)89649-1)
- [2] Melo IS, Faull JL, Graeme-Cook KA. Relationship between in vitro cellulase production of UV-induced mutants of *Trichoderma harzianum* (Rifai) and their bean rhizosphere. *Mycological Research*. 1997;101:1389-92. <http://www.sciencedirect.com/science/article/pii/S0953756208608047>
- [3] Avery PB, Faull J, Simmonds MSJ. Effects of *Paecilomyces fumosoroseus* and *Encarsia formosa* on the control of the greenhouse whitefly: preliminary assessment of a compatibility study. *BioControl*. 2008;53:303-16. <http://dx.doi.org/10.1007/s10526-007-9073-5>
- [4] Avery PB, Queeley G, Faull J, Simmonds MSJ. Effect of photoperiod and host distribution on the horizontal transmission of *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) in greenhouse whitefly assessed using a novel leaf model bioassay. *Biocontrol Science and Technology*. 2010;20:1097-111. <http://dx.doi.org/10.1080/09583157.2010.515299>

4. Details of the impact

Commercial products

Following the award of his PhD in 2001, Nicklin's student Pasco Avery continued to build on the work done with Nicklin at Birkbeck on whitefly control using *Isaria fumosorosea*. In particular, this has led to the licensing in the US of the biopesticide PFR-97™ (a commercial product formulation containing *Isaria fumosorosea*) for use on food crops. This product had for many years been licensed in Europe and Asia on a range of crops against whiteflies, thrips and other pests. Avery continued his work firstly at the United States Department of Agriculture Soil and Nutrition labs where other strains of this fungus were screened for their efficacy against pestiferous insects. As a post-doctoral researcher at Indian River Research and Education Centre, working closely with citrus growers, Avery continued his work on control methods against insect pests [a]. This led to the development of a tolerance residue limit exemption registration of PFR-97™ in 2011 [b], as Avery's research was used to justify a request to waive tests against non target insect species. Certis USA began selling PFR-97 for use on food crops in July 2012 and the product is now increasingly used to protect the vine crop in California against mite infestations that have become resistant to many foliar chemical sprays [c]. This product is also being used there commercially against other pestiferous arthropod pests of economically important crops. Sales in the USA have been growing faster than anticipated and Certis has now sold over 10,000lbs of the biopesticide for use on food and non-food crops. They are now planning to register PR-97 for use on food crops in Mexico.

Heritage consultation

Nicklin has worked with a number of heritage organisations, including English Heritage and the National Trust, monitoring and advising on the presence and hazard of fungal species in air and on collections. In the first instance, the primary concern of this consultancy work is health and safety, so that when mould is discovered, Nicklin advises on what type of protective equipment must be worn by conservators. The National Trust's National Specialists Consultancy Manager reports that "[Nicklin's] work in identifying mould spores and preventing their growth is not just important, but utterly essential to the National Trust's continuing practical physical care of its historic collections – as well as to the Health & Safety of its staff, volunteers and visitors" [d]. Nicklin has worked on properties including Windsor Castle, Coughton Court, Knole House, Christchurch College, Oxford and Dover Castle. This work has recently led to English Heritage and the National Trust jointly funding a PhD student.

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Nicklin also runs training sessions for both English Heritage and the National Trust. For the last four years, she has also taught on a course in Preventative Conservation run by West Dean college in Brighton. This is a continuous professional development course, which has been attended by professional conservators from a wide variety of institutions, including: English Heritage, the National Trust, Brighton Royal Pavilion, the Museum of Islamic Art in Qatar, the Tropenmuseum in Amsterdam, and many other local museums and galleries [e]. The course aims to equip participants with an understanding of the 'agents of deterioration' which affect the integrity of materials in collections, how to assess and prioritise those risks, and how to develop methods of mitigation which are appropriate in the context of each collection and its resources. Nicklin provided lectures and practical training sessions for the participants, enabling them to identify, risk assess and remediate mould infestations in their collections and libraries. One participant in 2013 said: *"In a nutshell, the course got us thinking about several issues surrounding conservation; sustainability in conservation, relative humidity and temperature, mould, pests, gaseous pollution, dust, light and lighting, emergency planning, objective setting, communicating conservation and the economics of preventive conservation (to name a few)"* [f].

Media/public engagement work.

As a result of her expertise in mould and fungi, Nicklin was invited to become the consultant microbiologist for the fifth series of Channel 4's *How Clean is your House?* This programme was viewed by an average of 1.7m viewers per episode when it was first shown in August 2009, and has been repeated many times since then [g]. Nicklin analysed swabs taken from the houses and then worked on location to ensure that the scientific content of the programme was accurate. In an interview with the Birkbeck College newsletter, Nicklin described her role as follows: *"I also made sure that they were getting the overall message right to the householder. We didn't want to terrify people. It's not car crash television. It's a sensible risk evaluation of the way some people live their lives. We were telling the householder, 'this is a very hazardous way of living your life. Here are some simple ways to clean up.' When Aggie revealed the lab results on set I'd make sure the householder didn't get panicked, and to answer questions, so it's fairly responsible"* [h].

In December 2012, Nicklin appeared twice on BBC Radio Four's *Broadcasting House* to discuss microbes in the old BBC studios [i]. Nicklin sampled throughout the old studios, including that of the Radio Four *Today* programme, and returned to discuss her finding that only the fridge was a source of potentially lethal microbes.

5. Sources to corroborate the impact

- [a] Biocontrol under study, Florida Grower, August 2009
<http://www.certisusa.com/pdf-technical/fungus-against-psyllids-august-2009.pdf>
- [b] Exemption from the requirement of a tolerance for PFR-97™
<https://www.federalregister.gov/articles/2011/09/28/2011-24990/isaria-fumoso-rosea-apopka-strain-97-exemption-from-the-requirement-of-a-tolerance>
- [c] Details of PRF-97 TM on the Certis US website:
http://www.certisusa.com/pest_management_products/bioinsecticide/pfr-97_microbial_insecticide.htm
- PFR-97 entering commercial use for viticulture throughout California:
http://www.certisusa.com/news/news_10022012_PFR-97_Bioinsecticide_Begins_Commercial_Use_in_California_Agriculture.htm
- [d] Corroborating statement provided by the National Specialists Consultancy Manager (London), National Trust. Copy available on request.
- [e] Link to course website:
<https://www.westdean.org.uk/CollegeChannel/CPD/Conservation/PCIPCourseDetails/PCIP201>

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[3/PreventiveConservation.aspx](#)

Copy of lists of course participants available on request.

- [f] Blog post written by one of the participants:
<http://arts.brighton.ac.uk/collections/design-archives/projects/conservationblog/preventive-conservation>
- [g] Viewing figures for *How Clean is Your House* Series 5, 2009 from www.barb.co.uk
- [h] Interview with the Birkbeck College newsletter:
<http://www.bbk.ac.uk/about-us/downloads/bbk23.pdf>
- [i] Copies of emails with producers of BBC Radio Four's Broadcasting House available on request.