Institution: University of Southampton

Unit of Assessment: 05 Biological Sciences

Title of case study: 05-08 Exosect: an innovative electrostatic technology for environmentally friendly pest control

1. Summary of the impact

Based on innovative technology invented and developed through research at the University of Southampton, sustainable pest control products by spinout company Exosect are being employed around the world to preserve the global food supply. Since 2008 its bio-control products have been newly adopted in diverse situations: by Sainsbury's in response to consumer pressure to reduce chemicals in food; by Bayer CropScience, who bought rights, in a multimillion pound deal, to a product for the protection of bee populations; by English Heritage to preserve the UK's cultural heritage. The technology has inspired a US$1m Gates Foundation grant for poverty reduction efforts in sub-Saharan Africa and raised awareness among conventional pesticide manufacturers of the environmental and economic benefits of bio-control solutions.

2. Underpinning research

Climate change and rising global populations mean that by 2050, food production must increase by a projected 70%. However, CABI International estimates that 40% of all food/fibre is lost to pests and diseases despite the overuse of synthetic pesticides.

During the 1990s University of Southampton researchers began investigating a more environmentally friendly alternative to synthetic insecticides. Inspired by the trapping mechanism of carnivorous pitcher plants, Philip Howse, Professor of Biology (1967-2001), patented the idea that a natural or synthetic powder with electrostatic properties could be used in pest management. After the patent publication in 1994, Howse worked on the proof of concept to formulate a unique electrostatic wax powder *Entostat*®, which went on to lie at the heart of all the products developed by subsequent University spin-out company Exosect.

The first application of *Entostat* was a cockroach trap invented by the Howse group in which a bait attracts the cockroaches and the powder destabilises them, causing them to fall into the trap – the same mechanism employed by a pitcher plant. Howse's group demonstrated that waxes have electrostatic charge generation and retention properties that allowed wax particles to adhere to the natural charge of the insect cuticle. Carnauba wax (a cuticular wax derived from natural plants) was identified as excelling in this desired property. Laboratory and field trials during the late 1990s demonstrated that *Entostat* could be used to deliver active ingredients to insect populations, although commercial sensitivity delayed publication until the early 2000s **[3.1]**.

Southampton researchers then explored the idea that combining *Entostat* powder with pheromones could disrupt mating cycles in a process known as 'auto-confusion'. Female moth pheromones were combined with *Entostat* in a tablet. Males were attracted to the mixture, which clings to them by static electricity and tricks them into trying to mate with each other. When combined with conventional synthetic chemicals, *Entostat's* targeted delivery reduced the volumes of chemicals required, thus producing a green bio-control **[3.2-3.4]**. Dr Jenny Knapp, Lecturer, University of Southampton (1993-2000), used pheromones to disrupt mating in codling moths **[3.5]**, later resulting in the development of *Exosex*® *CM*, one of the most successful products in Exosect's portfolio.

This body of research underpinned the formation of spinout Exosect in 2001. Howse became the company's Technology Director and the University appointed Guy Poppy (Senior Lecturer, 2001-2003, Professor of Ecology, 2003-present) to direct the Wolfson Unit of Chemical Entomology. In collaboration with Exosect, Poppy was awarded two Small Business Research Initiative (SBRI) grants from the BBSRC to work on a first-generation product for lepidopteran pests such as grape vine moths, and on lure and kill methods for the Mediterranean fruit fly which led to further underpinning research outputs **[3.3, 3.4, 3.6]**. These provided the mechanistic understanding

necessary for six of the seven management tools developed and marketed by Exosect.

Exosect remained in the University's business incubator until 2005 and Southampton staff continued collaborative research with Exosect on pest-control products. Dr Christopher Jackson (1985-current) and PhD student, Ian Baxter (2004-2008), demonstrated the efficacy of pheromones coupled with *Entostat* in the control of indoor moth pests, in particular the Indian meal moth **[3.6]**. This proved critical in the development of *Exosex SPTab*, the tablet that programmes pests to disrupt mating amongst their own population.

3. References to the research

Publications: (bold = UoS staff)

[3.1] McGonigle, D.F., Jackson, C. W. (2002) Effect of surface material on electrostatic charging of houseflies (*Musca domestica* L), *Pest Management Science,* vol 58 (4) p.374-380[3.2] Howse, P. (2004) Mechanism of Exosex auto-confusion system of mating disruption International Pest Control, vol 45 p. 321-322

[3.2] Howse, P.E. (2004) Mechanism of Exosex auto-confusion system of mating disruption. I*nternational Pest Control*, vol 45 p. 321-322

[3.3] Barton, L., Armsworth, C., Baxter, I., **Poppy, G.**, Gaunt, L., Nansen, C. (2006) Adhesive powder uptake and transfer by Mediterranean fruit flies, *Ceratitis capitata* (Dipt. Tephritidae), *Journal of Applied Entomology,* vol 130, p. 257-262

[3.4] Nansen, C., **MacDonald, K. M., Rogers, C. D.,** Thomas, M., **Poppy, G. M.,** Baxter, I. H. (2007) Effects of sex pheromone in electrostatic powder on mating behaviour by *Lobesia botrana* males *Journal of Applied Entomology,* vol 131, p. 303-310.

[3.5] Hughes WOH; **Gailey D**; **Knapp JJ** (2003) Host location by adult and larval codling moth and the potential for its disruption by the application of kariomones *Entomologia Experimentalis et Applicata,* vol. 106 (2), p. 147-153

[3.6] Baxter, I.H., Howard, N., **Armsworth, C. G., Barton, L. E. E., Jackson, C.** (2008) The potential of two electrostatic powders as the basis for an auto dissemination control method of *Plodia interpunctella (*Hubner) *Journal of Stored Product Research,* vol. 44 (2), p. 152-161

Research Funding

Elucidating the mechanisms of auto-confusion – a novel approach to lepidopteran mating disruption systems (BBSRC SBRI –Howse (Exosect) & **Poppy** (UoS) ca £200,000) – 2002-2004 (This grant included funding for a technician, Craig Rogers, who went on to work for Exosect and completed his masters at Southampton with Professor Poppy in 2012).

A modelling approach to improving lure and kill strategy for controlling fruit flies (BBSRC SBRI **Poppy (UoS)** & Howse (Exosect) ca £200,000) – 2004-2006.

Patent:

Patent GB2268676 Pest control: Inventor Philip Howse; Assignee University of Southampton; Published 19.01.1994.

4. Details of the impact

Research at the University of Southampton formed spinout company Exosect in 2001. The company's success since 2008, through products entirely based on Southampton's technology, has had a positive impact on global food supply chains and contributed to efforts to meet two of the UN Millennium Development Goals: eradicating extreme poverty and hunger, and ensuring environmental sustainability.

Exosect has grown to employ 20 staff, the majority of whom were trained or received postgraduate qualifications at the University, and has attracted more than £14.5m from investors (£10m since 2008) **[5.1]**. Since 2008 it has made 53 patent applications with 24 granted, and 22 national

product registrations **[5.2]**. Growing recognition of the environmental benefits of Exosect's products resulted in them winning 'Best New Product' for *Exosex SPTab* at the Society for Food Hygiene and Technology Awards in 2008 **[5.3]**, and winning their category in the Guardian Global Cleantech 100 awards (2009 and 2010) **[5.3]**.

Philip Harris, Business Manager at Exosect, said: "*Exosect simply wouldn't exist if it weren't for Howse's original vision; to use electrostatic powders in pest control management. The work done at the University through the 1990s to prove the viability of his concept was critical, and University backing was vital to help Exosect win initial investment funding. Poppy's contribution in securing two BBSRC grants was essential for designing better deployment strategies of our products and provided peer-reviewed journal articles, which increased confidence in Exosect's technology and products, helping us attract continued investment*" **[5.4]**.

Exosect licenses the use of its products, all using the *Entostat* formulation, to international distributors, benefitting governments and peoples around the world. It is estimated that 80% of EU crops currently depend, in part, on insect pollinators which are under threat. Bee populations are declining yet they pollinate nearly US$200bn worth of crops worldwide. *Exomite® Pro*, which treats against varroa mite in bees and reduces chemical residues on crops, came to market in 2004 when resistance to conventional pesticides was on the rise. In 2010, the rights to *Exomite Pro* were sold to Bayer CropScience for several million pounds (sum commercially confidential). Bayer said the acquisition would provide beekeepers with "*sustainable solutions to improve the health of their bees and beehives*" **[5.5]**.

The autoconfusion technology is employed in *Exosex CM* (codling moth), which holds an estimated five per cent market share for codling moth protection in apples and pears. In 2010, Sainsbury's highlighted its commitment to reducing pesticide residues in food by announcing that this product would be used on their UK apples. Sainsbury's sells one in four apples in the UK and their 'Concept Orchards' in Kent **[5.6]** have helped it treble apple yields from 20 tonnes to 60 tonnes per hectare **[5.7]**.

In Indian field trials the yellow stem borer product (YSBTab) improved rice yields by 18%, compared to conventional pesticides. The trials also found an 80% increase in beneficial insects **[5.8]**. With 44m hectares of rice grown annually in India, Exosect is in the process of licensing the product to a commercial partner. It will reduce the country's high dependency on pesticides - research shows that in one district in Andhra Pradesh there are more than 1,000 pesticide poisoning cases each year causing hundreds of deaths.

Stored moth product *Exosex SPTab* is used by multinational food manufacturers and retailers (names commercially confidential) to control moth populations in food processing plants, thus avoiding the need for harmful phosphine gas fumigation. Exosect is in the process of licensing the product to commercial partners in North America. In 2013 Exosect secured an exclusive license for a fungal isolate, from the Food, Environment and Research Agency in the UK to control grain store insects, and won a US$1m Gates Foundation grant to use the same technology to reduce poverty of subsistence farmers in sub-Saharan Africa **[5.9]**. Exosect's clothes moth product, *Exosex CLTab*, is backed by English Heritage, and is being used in public buildings around the country, including the Houses of Parliament, Hampton Court Palace and the Royal Opera House, to protect priceless collections from attack by clothes moths **[5.10]**.

The Exosect technology played a part in changing the legislative procedure for biopesticides, reducing red tape for bringing new products to market that are less harmful to the environment **[5.11]**. In partnership with DEFRA, Exosect included *Exosex CM* in a pilot Biopesticides Scheme that inspired legislative changes in the mid 2000s. The impact is ongoing; the new legislation stimulated interest among the dominant conventional pesticides manufacturers in the potential of biological control techniques. Exosect says that "*within the last two years, in light of reduced regulatory hurdles, over US$2bn has been invested by leading agrochemical companies in buying up biological specialists e.g. Bayer's purchase of Exomite Pro"* **[5.4]**.

5. Sources to corroborate the impact

[5.1] http://www.pestmagazine.co.uk/content/NewsItem.aspx?id=326

http://www.exosect.com/media_news/documents/ExosectSecuresOver2.25mFundingtoSupportNewProductLaunches.asp?css=1&pg=5

[5.2] For evidence of IP portfolio see www.exosect.com (under 'Products') and list of patents.

[5.3] "Best New Product" at the Society for Food Hygiene and Technology Awards in 2008 http://www.exosect.com/media_news/documents/ExosectWinsAtTheSOFHTAnnualAwards.asp?css=1&pg=6 and winning their category in both Guardian Global Cleantech 100 awards (2009 and 2010)

http://web.archive.org/web/20110121073646/http://www.guardian.co.uk/globalcleantech100/cleantech-100-2010-list and

http://www.exosect.com/media_news/documents/ExosectNamedA2010GlobalCleantech100Company.asp?css=1&pg=4

[5.4] Business Operations Manager, Exosect

[5.5] http://www.reuters.com/article/2010/11/16/idUS236581+16-Nov-2010+MW20101116 and http://www.exosect.com/media_news/documents/BayerCropScienceAcquiresGreenBeeHealthProductFromExosect.asp?css=1&pg=4

[5.6] http://www.j-sainsbury.co.uk/media/latest-stories/2010/20100411-gay-moths-to-help-growers-protect-british-apple-crop/ and

[5.7] http://www.j-sainsbury.co.uk/responsibility/case-studies/2011/concept-orchards/

[5.8] Baby biotech stops bugs munching by Catherine Wheatley, The Sunday Times Published: 27 November 2011

http://www.thesundaytimes.co.uk/sto/business/Industry/article830612.ece

[5.9] http://www.prlog.org/12066691-uk-firm-exosect-ltd-moves-forward-with-food-security-project-in-africa.html and

http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2012/11/OPP1052676

[5.10] Higgs, S. & Bridal, J.(2011) Moths, Exosex and Floor Voids at Hampton Court Palace
Lauder, D. (2011) The Exosex clothes moth system and English Heritage
Both in Integrated Pest Management for Collections: Proceedings of 2011: A Pest Odyssey, 10 Years Later. Eds P. Winsor, D. Pinniger, L. Bacon,B. Child, K. Harris, D. Lauder, J. Phippard & A. Xavier-Rowe.Swindon, UK: English Heritage, pp. 61–5.

[5.11] http://www.pesticides.gov.uk/guidance/industries/pesticides/user-areas/biopesticides-home