

# David Phillips Fellows - Social and policy impacts

BBSRC's David Phillips Fellows are tackling some of the major challenges facing people around the world. In recent years, the research conducted by scientists awarded a prestigious David Phillips Fellowship has addressed issues as diverse as helping to control devastating infectious diseases to protecting biodiversity or reducing laboratory animal use.

As a result, their research has influenced international policy discussions, improved working practises, and protected human health and well-being.

This case study describes four examples:

- Dr Heather Ferguson at the University of Glasgow who is studying the ecology and evolutionary biology of malaria-carrying mosquitoes in Tanzania. She has successfully trained African PhD and MSc students who are now working in Tanzania to understand and control the mosquitoes.

- Dr Mark Whittingham at the University of Newcastle, whose research into the effects of habitat on farmland birds has been incorporated into Natural England's agri-environment scheme guidelines to help farmers protect the biodiversity on their farms. The guidelines have been used by thousands of farmers on tens of thousands of hectares of UK farmland.

- Dr Mark Webber's work at the University of Birmingham has helped researchers and policy-makers understand how certain disinfectants can cause bacteria to develop resistance to antibiotics. The results have informed two reports produced by European Union Scientific Advisory Committees.

- Dr Andrea Graham completed her fellowship at the University of Edinburgh. Her research into the mammalian immune system led to a statistics paper that is helping immunologists reduce the number of animals they use in their experiments.

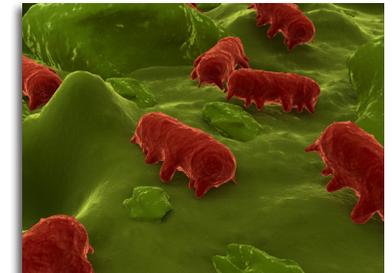
## What are David Phillips Fellowships?

Launched in 1996, the prestigious BBSRC David Phillips Fellowships are designed to support outstanding scientists in the early stage of their research careers to establish themselves as independent researchers.

David Phillips Fellowships are awarded for five years. They include a personal salary and a significant research support grant.

The Fellows are assigned an independent mentor who can provide professional advice and guidance. They also have the opportunity to attend training courses and BBSRC's biennial Fellows' Conference.

Up to ten David Phillips Fellowships are awarded per year.



## Building research capacity to tackle malaria

*African postgraduate students trained by David Phillips Fellow Dr Heather Ferguson are helping to understand the ecology of malaria-carrying mosquitoes in Tanzania. They are using this knowledge to monitor and control mosquitoes with the aim of reducing the number of malaria cases in communities where people are at high risk of infection.*

“Tanzania has one of the highest malaria burdens in the world: there are around 100,000 deaths a year from malaria.”<sup>1</sup> says Ferguson, a David Phillips Fellow at the University of Glasgow<sup>2</sup> who studies the ecology and evolutionary biology of the mosquitoes that transmit malaria.

However, according to an opinion piece co-authored by Ferguson, “Our understanding of the ecology of mosquitoes that transmit malaria lags decades behind that of agricultural pests, endangered species, and model organisms.”<sup>3</sup> By understanding the links between mosquito ecology, behaviour and their ability to transmit disease, Ferguson aims to reduce the number of cases of malaria. For instance, one strand of her research is exploring how the presence of domestic animals such as cattle and other livestock affects mosquito feeding patterns and their biting rates on people. “Anything we can do to change [mosquito] behaviour would have a major impact”, Ferguson adds.

One of the major obstacles to creating and implementing malaria control in low-income settings such as Tanzania is the scarcity of training opportunities in disease

research for students and scientists. Ferguson has been helping to build research capability by training African postgraduate students in the ecology of malaria mosquito vectors and how to control them in their home countries.

Throughout her fellowship Ferguson has been working closely with the Ifakara Health Institute (IHI) in Tanzania<sup>4</sup>. Working with IHI has given Ferguson access to local expertise, laboratory facilities and data. “Ifakara is an international centre of excellence in malaria research, situated right in the heart of the African communities where the problem is most pronounced. They’re working right at the coal-face at some of the world’s highest malaria transmission,” says Ferguson. However, the challenge facing IHI researchers is that without a PhD they cannot access much of the international scientific community, despite their thorough understanding of the problems surrounding the spread of malaria and many years’ experience studying the disease in Africa.

Yet Ferguson is clear that such training has a real and demonstrable impact: “You often don’t know the impacts of basic research straight away, but if you train good African students the impact can be immediate.”

For example, one of the PhD students Ferguson supervised during her fellowship, Dr Issa Lyimo, is now Director of Research at the Ifakara campus of IHI. According to Lyimo, “[Ferguson’s fellowship has] made a substantial contribution on efforts to design effective malaria control strategies through improving

### Impact Summary

Ferguson has trained a PhD and an MSc student who are now working with local communities to tackle malaria. One, Dr Issa Lyimo is now the Director of Research at the Ifakara Health Institute. Ferguson has also trained three other students before and after her fellowship.

The fellowship has also allowed Ferguson to leverage international funding from the National Institutes of Health (NIH) in the USA and the EU’s Framework Programme 7.

### Future Impacts

Ferguson’s preliminary results hint at novel strategies to reduce the number of bites local people receive from malarial mosquitoes. The results will be published shortly and presented to the Tanzanian government.

our fundamental understanding of mosquito ecology, behaviour and evolution. I believe this knowledge is vital to aid development of new malaria vector control strategies, but this type of training is often difficult for African public health scientists to access.”

“... it was the combination of research and leadership skills acquired through training provided through this BBSRC fellowship that has allowed me to progress my career in my subsequent role as the Director of Research at the Ifakara campus of Ifakara Health Institute, one of Africa’s leading public health research institutes. In this post I will be able to pursue my career working for the betterment of communities in Tanzania and Africa at large,” says Lyimo.

In addition, Ms Valeriana Mayagaya, who conducted her MSc research under Ferguson’s supervision (and in collaboration with the University of Dar es Salaam), is now working at IHI as a research scientist. Mayagaya studied how the presence of livestock and other domestic animals can help reduce human exposure to malaria. Ferguson also trained two other Tanzanian postgraduate students before her fellowship began and has recently started training another PhD student.

The fellowship has also enabled Ferguson to secure more funding to continue investigating the mosquitoes that carry malaria, including grants from the NIH and the European Union Framework Programme 7 (EU FP7). “[The NIH grant] is directly grounded in my fellowship work. Colleagues from IHI and I suspect that mosquitoes

may be modifying their behaviour to avoid bednets, by biting people early in the evening or outside where they’re not protected by bednets,” says Ferguson. The researchers saw indications that this was happening during Ferguson’s fellowship, and the NIH grant will allow them to investigate further.

Ferguson is also contributing to the mosquito entomology aspects of a large EU FP7 project by developing new tools for detecting mosquitoes that may have adopted these ‘unconventional’ biting habits and behaviours. She has also recently received funding from the Medical Research Council to investigate the spread of a type of malaria in south-east Asia which appears to have crossed over from monkeys into humans, following an outbreak of the disease in Borneo.

Malaria is a major global health problem and 3.5 billion people in 109 countries are at risk from the deadly disease. 35 countries account for 98 per cent of global malaria deaths, including 30 countries from sub-Saharan Africa <sup>5</sup>.



Dr Issa Lyimo and Dr Heather Ferguson setting up experiments on mosquito behaviour at the IHI, Tanzania. Credit: IHI/University of Glasgow



Conducting fieldwork in the Kilombero Valley with M.Sc. student Valeriana Mayagaya. Credit: IHI/University of Glasgow

# Improving farmland environmental management

*Research by David Phillips Fellow Dr Mark Whittingham into the effects of habitat structure on farmland birds has been used by Natural England to inform the Environmental Stewardship scheme guidance given to farmers. 8,885 farmers have signed agreements to mow the grass buffer strips around their fields to benefit kestrels, and 5,744 have agreed to manage winter stubble on their fields to help other farmland birds such as skylarks.*

“Farmland bird populations have declined more rapidly than bird populations in other habitats,” says Dr Mark Whittingham, from Newcastle University <sup>6</sup>. As a result, Whittingham’s fellowship focussed on how farmland bird populations are affected by farmers’ land management practices, and how those practices could be adapted to protect and support biodiversity. Throughout his fellowship, Whittingham worked closely with Natural England; “My aim was a management tool that could be used across agri-environment schemes.”

The UK’s National Ecosystem Assessment found that 40% of the UK is covered by enclosed farmland; more than any other habitat type <sup>7</sup>. The NEA also suggests that the ‘non-use’\* value of the UK’s terrestrial biodiversity is around £845m per year <sup>8</sup>.

Whittingham found that “...most species of conservation interest preferred short stubble.” This suggests that farmers trying to support biodiversity on their farms can help bird populations by cutting their

stubble – the stalks left in the ground after crops have been harvested – much shorter than was existing practice.

The results helped to set the guidance given to farmers who sign agreements under the Environmental Stewardship agri-environment scheme, which pays farmers who agree to manage their land in an environmentally-friendly way. “It’s really good for us to have academics that are interested in the applied aspects of their work,” says Phil Grice, Senior Environmental Specialist, Ornithology, at Natural England, “as we’re talking about delivering biodiversity commitments at an international level, and [spending] millions of pounds of public money.”

Grice added, “Mark’s work has helped us design management options within our stewardship schemes that are evidence-based and so have a high likelihood of achieving outcomes on the ground. A popular option in the schemes is to retain stubble over winter, which is designed to provide good feeding sites for seed-eating birds.” He continued, “We have growing evidence that they are doing just that.”

Natural England keeps track of how many agreements have been signed by farmers, and the area of land covered by individual options. The data reveal that 5,744 agreements include winter stubble options that incorporate Whittingham’s results, applying the findings to 89,137 hectares of land in England.

During his fellowship, Whittingham also co-supervised

## Impact Summary

The results informed Natural England Environmental Stewardship agri-environment scheme option guidelines on managing field margin buffer strips and over-winter stubble.

So far, farmers and land managers have signed 8,885 agreements including the field margin option with Natural England, including a total of 19,754 hectares. For the over-winter stubble option, Natural England has 5,744 agreements covering 89,137 hectares of UK farmland.

Whittingham’s research has also shown that windfarms do not adversely affect winter populations of many farmland birds.

the work of a PhD student with Grice, and the results of that study informed a second option in the Environmental Stewardship scheme. The work looked at how kestrels forage in grass buffer strips around fields. Buffer strips are "...like a margin two to six metres wide around fields", says Grice. "Margins are very good places for small mammals, so they're good for kestrels who feed on them. But kestrel populations declined, so how could this happen as we've put out thousands of miles of larder for them?"

Whittingham's research showed that, although the long grass on the margins provided excellent habitat for the small mammals, it made it harder for the kestrels to hunt them. Mowing part of the buffer strips makes it easier for the kestrels to catch their prey, and this has directly influenced the option included in the agri-environment scheme. Grice explains; "For six metre buffer strips we require the outer three metres to be cut once a year to increase the heterogeneity of the habitat." So far, 8,885 agreements include the six metre buffer strips option, covering 19,754 hectares of grass buffer strips.

As well as influencing the scheme itself, Whittingham's work has informed additional guidance notes produced by Natural England for their staff and farmers looking to take their environmental management further than the requirements of the options. It has also informed RSPB guidance notes for the Environmental Stewardship scheme <sup>9, 10</sup>.

A study of bird populations around two wind turbines in East Anglia also allowed Whittingham to demonstrate that windfarms have little effect on many farmland bird populations over winter <sup>11</sup>. The results will reassure land owners, policy-makers and conservationists concerned that meeting renewable energy targets by building new wind farms could adversely affect farmland biodiversity.



Credit: Mark Whittingham

### Environmental Stewardship

Natural England's Environmental Stewardship scheme is an agri-environment scheme designed to help farmers and others develop an effective environmental management policy for their farm.

At the entry level, which was introduced in 2005, the farmers choose a set of environmental management 'options', completion of which is worth a certain number of points. By accumulating enough points, the farmers can qualify for a payment of £30 per hectare, thus encouraging them to adopt measures that help to protect the environment and the biodiversity on their farms.

For more information, see: <http://www.naturalengland.org.uk/ourwork/farming/funding/es/els/default.aspx>

## Informing EU reports on antibiotic resistance in *Salmonella*

*David Phillips Fellow Dr Mark Webber has characterised the genetic changes which grant Salmonella bacteria resistance to a common household disinfectant and which can also result in multi-drug resistance. The results of Webber's work have been used by European Union Scientific Advisory Committees in two reports on the use of disinfectants.*

The disinfectant triclosan can be found in soaps, deodorants and other household products. However, it is relatively easy for bacteria such as *Salmonella* to develop resistance to triclosan, and this can also make them resistant to antibiotics. During his fellowship, Dr Mark Webber from the University of Birmingham<sup>12</sup> used a variety of techniques, including genomics, proteomics and transcriptomics, to describe the genetic changes that underpin this resistance.

The results of Webber's research were used by the EU's Scientific Committee on Consumer Safety<sup>13</sup> and the Scientific Committee on Emerging and Newly Identified Health Risks<sup>14</sup>. "The EU published two reports; one specifically about triclosan, one about biocides generally. They used six of our papers," says Webber. The Scientific Committee on Consumer Safety report directly refers to Webber's results, as it states that "... the identification of mechanisms of microbial resistance including genomic and proteomic aspects, is commendable and should be extended to other biocides".

Around 10,000 cases of *Salmonella* food poisoning were reported in the UK in 2009, although

researchers predict that this may reflect less than one third of the total number of cases as many people do not report food poisoning to their doctor<sup>15</sup>. Although *Salmonella* infections are rarely fatal, they usually result in diarrhoea and fever and can take up to a week to clear, causing suffering and reducing economic productivity. Drug-resistant *Salmonella* strains can cause more serious illness and more deaths than non-resistant strains<sup>16</sup>.

*"The EU published two reports.... They used six of our papers."*

According to Webber, "The main finding [of the fellowship research] is that resistance is due to a metabolic shift"<sup>17</sup>. Triclosan usually blocks part of the bacteria's metabolism which manufactures fatty acids. Resistant bacteria have altered their metabolism to avoid this blockage. Highly resistant strains also produce more 'efflux pumps' – proteins that pump toxins out of the bacterial cells – which helps them resist the effects of various toxins, including antibiotics. Webber also showed that a small number of *Salmonella* isolated from people and animals had low levels of triclosan resistance<sup>18</sup>, and that more than half of those are also multi-drug resistant.

During his fellowship, Webber was also invited to join the expert panel of CAAMIC (the Centre for Application for Advanced Materials in Infection

Control). CAAMIC<sup>19</sup> provides advice to companies developing new ways to tackle hospital infections and, while Webber was on the panel, the group gave companies the opportunity to pitch for funding to run a small trial of their technology in an NHS hospital. Webber was asked to join the group because many of the technologies proposed were biocides and disinfectants. For instance, Webber advised one company seeking to incorporate silver, a powerful biocide, into surfaces and equipment in hospitals.

### Impact Summary

Webber's results, demonstrating the genetic basis of multi-drug resistance in *Salmonella*, were used in two EU policy reports on triclosan and general disinfectant use.

Webber was also invited to join the CAAMIC expert panel where he advises companies interested in working with the NHS to test and deploy new infection-fighting technologies in hospitals.

## Reducing the number of animals used in immunology research

*Dr Andrea Graham<sup>20</sup>, who completed her David Phillips Fellowship at the University of Edinburgh, published a statistics paper that has helped reduce number of animals used in immunological research. Graham and colleagues have since been asked to write a statistics textbook specifically aimed at immunologists.*

“[The paper came] from my frustration with the rather low standards for statistical analysis in immunology,” Graham says. Despite the importance of statistical analyses in immunology, there were no standard guidelines demonstrating how statistics should be applied to such research.

Working with colleagues from University College London and the University of Reading, Graham wrote the paper and submitted it to top immunology journals. It was accepted and published by the journal *Immunity*. “We were pleased one of the top journals in immunology was willing to publish this, as we were quite critical of those journals,” Graham adds.

*“We have been asked to write a textbook for immunologists.”*

Graham has since received feedback that the paper is proving useful for researchers. “Word of mouth [suggests] that people found it useful, particularly

for calculating sample size before doing experiments.” Following publication, Graham and colleagues were approached to take the work even further; “We have been asked to write a textbook for immunologists,” says Graham.

In the UK, researchers conducted around 3.7 million procedures involving animals in 2010<sup>21</sup>. The UK’s Animals (Scientific Procedures) Act 1986 specifies that “the number of animals used and their suffering must also be minimised” before projects are granted a licence to use animals in research<sup>22</sup>. By using an appropriate number of animals in an experiment, researchers will ensure no animals suffer unnecessarily. They will also make sure they only need to run the experiment once or twice, rather than repeating it many times. “Per experiment sample size may be larger, but overall sample size is smaller.” explains Graham.

By designing better experiments and carrying out appropriate statistical analysis, immunologists will also improve the quality of their results, which are often used by pharmaceutical companies such as vaccine manufacturers.

Graham’s interest in and knowledge of statistics arose from her background in ecology and evolutionary biology, where she needed to apply complex statistical analyses to take account of the many inter-related variables that could affect an ecosystem. She approached immunology in the same way. “You can think of an individual host body as an ecosystem,” Graham explains. “Again, there are many different sources of variability.”

Graham’s fellowship research concentrated on the response of the mammalian immune system when it was exposed to several parasites and infections at once. “Most animals harbour several parasites at any one time, but the mammalian immune system is impaired in its ability to multitask,” he says. According to Graham, such co-infection is a common problem. “Almost one third of *Homo sapiens* have an underlying parasitic worm infection and on top of that you have influenza and other infections requiring immunological attention.”

### Impact Summary

Graham’s paper, ‘t-testing the immune system’, has been used by immunologists to refine their experimental design, reducing the number of animals used.

As a result, Graham and colleagues have been asked by a publisher to expand their work into a statistics textbook aimed at immunologists.

## Notes and references

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BBSRC conducted an evaluation of the David Phillips Fellowships in 2011. The full report can be found at: <http://www.bbsrc.ac.uk/organisation/policies/reviews/funded-science/1109-david-phillips-evaluation.aspx>

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