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War report: fighting armyworms in Africa

Following a long-term reconnaissance, BBSRC-funded researchers are leading international efforts to halt the devastating advance of armyworms.

Many important jobs require people to be on call, waiting for the phone to ring and to spring into action at a moment's notice. For BBSRC-funded Professor Kenneth Wilson at Lancaster University, the call doesn't take him to a hospital, an accident, or even an office. Between October and April in any year, when Wilson gets the call he embarks on a research trip to Africa where he combats the march of serious insect crop pests called armyworms that can devastate agricultural production and cause food security issues in many countries across eastern and southern Africa.

Control strategy

The African armyworm, *Spodoptera exempta*, is an insect pest of widely grown cereal crops such as maize, wheat and rice. These 3cm-long insects can reach plague-like densities of 200-1,000 caterpillars per square metre. Outbreaks can occur throughout sub-Saharan Africa but mostly originate in primary outbreak areas in Tanzania and Kenya (Ref 2) before over several generations, spreading to Zambia, Uganda and even as far as South Africa and Yemen.

Wilson has been studying armyworms for nearly 25 years. During this time he's seen that most resource-poor farmers in Africa cannot afford imported pesticides, and those who can are not properly equipped to protect themselves from the noxious chemicals.

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Armyworm caterpillars devastate important food crops across entire countries.

Having witnessed the plight of these farmers first hand, he, together with colleagues at the University of Greenwich and a small Tanzanian business, Crop Biosciences Ltd, have spent the last 15 years looking to see whether a viral disease of the larval stage of the armyworm, called SpexNPV (for *Spodoptera exempta* nucleopolyhedrovirus), can be harnessed as a cheaper and safer biological control agent (Ref 1).

And as part of a research project supported through the SARID (Sustainable Agriculture Research for International Development) initiative, which was co-funded by BBSRC and the Department for International Development (DFID), Wilson has helped to establish a state-of-the-art laboratory in Tanzania, which can formulate the virus locally to counter the threat. This means that the use of expensive imported chemical pesticides could be drastically reduced. The use of local expertise also helps to develop indigenous skills and promote more equal knowledge exchange.

Spreading the word

Wilson's expertise is also collated on his Armyweb website that carries news and outbreak forecasts as well as summaries of his research. Armyweb was seen by Paul Desmarais, who runs the Kasisi Agricultural Training Centre in Lusaka, Zambia. He wanted advice on non-chemical means of controlling armyworms because they grow crops organically. "I told him about SpexNPV and he was keen to learn more. So I decided to go to Zambia to assess the situation for myself and to meet with him," says Wilson. "As soon as I had confirmed that I would be going, Paul phoned the Zambian Vice President, who he knows, to suggest that the two of us meet so that I could advise the government on mitigation options, including biocontrol."

Wilson says they also discussed specific measures to tackle the looming food security crisis: replant the crops that had been destroyed (which they had already begun to do), and ensure they had a working pheromone trap network to monitor subsequent armyworm adult moth movement, which would tell them where the next outbreaks would be.

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Professor Kenneth Wilson, Lancaster University

moths migrate hundreds of kilometres, it was just as likely to be one of the neighbouring countries in the south, such as Zimbabwe, Malawi and Botswana," Wilson explains. In fact, all of these countries subsequently reported extensive outbreaks.

Hopeful harvest

Analysing details of an organism's life cycle might seem an old-fashioned way to go about modern biology but, combined with genetic analysis of the virus, these fundamental insights into the behavioural ecology of the insect could turn a ubiquitous virus into a safe, environmentally friendly biopesticide.

And it could all be a matter of timing and applying the virus, which can be sprayed from a conventional machine or sprayed from an aeroplane (ref 2). Hitting the armyworms with SpexNPV in early season is best because this will have the biggest impact on the growth of the armyworm population as each infected larva will produce more than two billion new infective particles to cascade control. Applying the viral biopesticide early also allows plenty of time for new stocks of virus to be harvested for later use.

Using a cocktail of viral genotypes increases mortality compared to a single isolate, probably because armyworms vary in terms of which virus genotype they are most susceptible to. This favours local field production of the virus because a single, most efficacious strain does not have to be isolated which can be expensive, time consuming and technically challenging. Avoiding overuse of just one strain also greatly reduces the likelihood of resistance evolving.

And there's a recent, but significant, twist to the story. Working under the BBSRC/DFID SARID programme, Wilson and colleagues have found that armyworms infected with a bacterium called *Wolbachia* are between six and 14 times more susceptible to SpexNPV than armyworms which have had their bacterial passengers removed (ref 3). It's an intriguing finding, because the presence of *Wolbachia* often confers resistance to viruses to their insect hosts, as seen in mosquitoes which carry the virus that causes dengue fever.

The finding also opens up an additional avenue for control: SpexNPV plus *Wolbachia*. And with six countries in Africa experiencing outbreaks in early 2013, the need is as great as ever. In Zambia alone, Wilson says, armyworm outbreaks were reported in seven of the country's 10 provinces; more than 96,720ha of maize and pasture were infested, affecting close to 73,000 farmers.

It's not surprising that the Zambian Vice President was very interested in the work Wilson and colleagues are doing with field-produced SpexNPV, and expressed interest in conducting field trials in Zambia under a research license. However, Wilson says his team's priority this year is to produce a formulated product that could be registered for sale. "I explained that it would be simpler to import it from Tanzania, where the new production facility is, but first Crop Biosciences need to register the formulated product in Tanzania and then elsewhere in Africa."

Harvesting infected larvae to produce a biopesticide.

Further Reading

Watch a video feature at www.youtube.com/watch?v=7OHYQu7a7Ic

www.lancs.ac.uk/staff/wilson4/ARMYWEB/ARMYWEB.html

1 Evaluation of *Spodoptera exempta nucleopolyhedrovirus* (SpexNPV) for the field control of African armyworm (*Spodoptera exempta*) in Tanzania. *Crop Protection* DOI: 10.1016/j.cropro.2007.04.005,

2 Novel technologies for control of African armyworm on smallholder cereals in East Africa. http://bit.ly/10VTwBz

3 *Wolbachia* in a major African crop pest increases susceptibility to viral disease rather than protects. *Ecology Letters* DOI: 10.1111/j.1461-0248.2012.01820.x

Next steps

- Register a formulated SpexNPV product in Tanzania and build up large stocks of SpexNPV to facilitate Africa-wide 'strategic' biocontrol of armyworm and monitor its consequences in terms of improved food security
- Obtain a better understanding of the interaction between *Wolbachia* and baculoviruses
- Determine the mechanisms and consequences of the large amounts of genetic variation in the SpexNPV virus and to establish whether armyworm resistance varies between hosts and across virus strains

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Discovery pipeline