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Viruses as biopesticides

By Michael Jukes and Marcel van der Merwe

Viruses are generally perceived as an enemy of the people, and for good reason, given the often devastating outcomes of viruses such as the COVID-19 coronavirus, Ebola and HIV, and the nuisance of rhinoviruses, responsible for the common cold. But as with many things in life, viruses can be manipulated to our benefit. The tight evolutionary bond between viruses and their hosts often means there is a very narrow range of organisms that they can successfully infect. Entomopathogenic viruses, for example, primarily infect insects, and have become a valuable and highly effective tool in the fight against insect pests of agricultural crops.

Viruses used in biological control have several advantages over other forms of pest control. They are highly diverse, with many distinct species classified to date. These species have themselves been shown to vary genetically, with unique isolates often found in geographically separated regions across the globe. This provides us with a rich library of biological agents that can be developed into biopesticides. Viruses are also self-replicating organisms, which enables them to spread within host populations and persist in the environment for long periods of time. Compared to most chemical insecticides, the application of virus-based biopesticides in the field is far less detrimental to our beneficial insects, such as bees and parasitoids, due to their narrow host range. This results in a more environmentally friendly approach.

The Virus Research Group (VRG) and the Centre for Biological Control (CBC) at Rhodes University have been working to harness the benefits of entomopathogenic viruses for many years. Pests such as codling moth, cotton bollworm, diamondback moth and false codling moth cause immense damage to important crops such as apple, tomato, potato, rice and citrus, among many others. For each of these pests, projects were initiated to isolate, identify and evaluate indigenous strains of viruses that can be utilised on farms as pest control agents.

The basic process involves the establishment of an insect colony, which is regularly checked for any larvae exhibiting symptoms of a viral infection, such as becoming lethargic and pale in appearance. As the infection progresses, larvae begin to climb upwards in a somewhat 'zombified' state. In a natural environment, the virus triggers cells to rupture, releasing viral particles back into the environment and contaminating the surrounding plant material to be ingested by its next host. However, if collected at this stage, it can be purified, studied and developed into a biopesticide.

To date, the CBC and VRG have identified many South African virus isolates, including *Cryptophlebia peltastica* nucleopolyhedrovirus (CrpeNPV), *Cryptophlebia leucotreta* granulovirus-SA (CrleGV-SA) and *Cydia pomonella* granulovirus-SA (CpGV), to name a few. All these viruses are grouped under a single family, the Baculoviridae, with many known to only infect lepidopteran insects (moths and butterflies), making them ideal candidates as biocontrol agents.

Of all the viruses worked on at the CBC and VRG, CrleGV-SA serves as a prime example of how these viruses have been taken from the field and developed into effective

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Culturing yeast isolated from false codling moth larvae for volatile testing.

biopesticides to control agricultural pests. Once isolated and identified, an extensive range of laboratory tests and field trials were conducted to determine the optimal concentration and how best to apply the virus. CrleGV-SA was formulated into a liquid spray that can be easily applied to citrus crops, using standardised farming equipment. For nearly two decades now, this virus has been successfully applied in the field to control false codling moth in South Africa. However, our work is far from complete. A number of challenges arise with the use of viruses as control agents. This includes their slow speed of kill, their susceptibility to UV light and the development of host resistance.

These challenges led to the initiation of several novel projects, each aiming to improve aspects of this virus to ensure its continued use in the field. One of these projects is exploring the beneficial effects of combining the virus with yeast. While this may sound like a strange idea, certain yeasts have been shown to have a synergistic relationship with lepidopteran insects. Experiments conducted with the false codling moth and yeasts isolated from the field have already shown that they prefer fruit sprayed with yeast over those without. Furthermore, combining the virus with yeast has resulted in higher levels of pest control than when used on its own. The project is now moving towards identifying the volatiles produced by the yeast, which are responsible for attracting the moths. Identification of these compounds may lead to the formulation of highly attractive bio-pesticides, or the development of novel lures for the monitoring of pests in the field.

One of the more recent developments at the CBC and VRG was the discovery of the virus species, CrpeNPV. This virus was isolated from the litchi moth, a major pest of litchi in South Africa. The true importance of this virus was stumbled upon while testing its host range. Experiments soon revealed that this virus also infects false codling moth and codling moth. This discovery will enable the virus to be utilised in multiple markets around the world against three major pests, protecting a variety of different crops. The discovery is even more important given the recent rise of resistance in codling moth populations in Europe to its homologous virus, CpGV, which has been in use for several decades as a biocontrol agent. The strategic application of CrpeNPV, in combination with viruses already in use in Europe and South Africa, could serve as a resistance management and prevention tool.

The CBC and VRG at Rhodes University will continue to advance the use of entomopathogenic viruses for the control of important agricultural pests in South Africa. Through innovative projects, strategic industry partnerships and responsible use of chemical insecticides and biological pesticides, a stronger agricultural industry can be developed, which can simultaneously reduce our impact on the environment.

The authors are based at Rhodes University's Centre for Biological Control and Virus Research Group, where Dr Michael Jukes is a postdoctoral researcher and Marcel van der Merwe is completing his PhD.

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The false codling moth

The false codling moth, *Thaumatotibia* (formerly *Cryptophlebia*) *leucotreta*, is indigenous to sub-Saharan Africa, but has spread throughout the continent and has also become established in parts of Israel. As well as being a major problem in the citrus industry, it is a pest of many other crops, including macadamia, avocado, peaches, apples, cotton and sorghum. Its economic impact is not limited to direct losses of produce – biosecurity officials at international borders may prevent entry of entire consignments if infected produce is detected, or even put a ban on imports from certain regions.

In oranges, the female moth lays her eggs on the surface of the fruit, and the larvae burrow through the rind after hatching to feed on the soft flesh inside. This not only spoils the fruit, but also provides an entry point for other pests and pathogens. The final larval instar emerges from the fruit and drops to the ground on a silken thread, before burrowing below the soil surface to pupate inside a cocoon.

Various methods are used to control false codling moth in South Africa, including chemical insecticides, pheromone traps, mating disruption, sterile insect technique, and biological control by parasitoid wasps. Entomopathogenic nematodes (EPN) and fungi (EPF) that control the soil-dwelling stages of the pest have also shown promise as biocontrol agents.