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Entomopathogenic Viruses: A Green Solution for Sustainable Control of Insect Pests

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Abstract

Entomopathogenic viruses (EPVs) are emerging as an environmentally sustainable solution for controlling insect pests, offering an alternative to conventional chemical pesticides. These natural pathogens, including nucleopolyhedroviruses (NPVs) and granuloviruses (GVs), specifically target pest species, reducing the impact on non-target organisms and promoting ecological balance. EPVs are gaining traction due to their ability to contribute to integrated pest management (IPM) systems, especially in agriculture. In recent years, EPVs have accounted for a significant percentage of biopesticide formulations, contributing to approximately 30% of the global biopesticide market. Their benefits include low environmental toxicity, biodegradability, and minimal resistance development, making them a key component in the sustainable management of pest populations. The mass production of EPVs, advancements in genetic engineering to enhance virulence, and the development of novel formulations are paving the way for their wider adoption. Despite challenges such as high production costs and limited host range, the growing interest in EPVs offers hope for reducing the reliance on chemical pesticides and fostering more sustainable agricultural practices worldwide.

Keyword: Entomopathogens, NPV, Biological control, IPM

1. Introduction

Entomopathogenic viruses (EPVs) are a group of viruses that specifically infect and cause disease in insect pests. These viruses, including nucleopolyhedroviruses (NPVs), granuloviruses (GVs), and other insect-specific viruses, are natural biological agents that lead to the mortality of their hosts. EPVs are defined as viruses that infect insects, causing systemic infections that result in the death of the pest, typically through mechanisms such as cell lysis, disruption of physiological processes, or paralysis. These viruses are highly specific to their host insects, which reduces their impact on non-target species and makes them a valuable tool for sustainable pest management. EPVs function as a natural form of biological control, providing an environmentally friendly alternative to chemical pesticides. Their potential role in sustainable pest management is significant, especially in addressing challenges such as pesticide resistance, environmental pollution, and the need for more eco-friendly crop protection solutions (Fuxa & Tanada, 2023). By integrating EPVs into pest management programs, particularly in agriculture, there is an opportunity to reduce dependence on synthetic chemicals, preserve biodiversity, and promote long-term sustainability in food production systems. As research and technology continue to advance, EPVs are poised to play a critical role in integrated pest management (IPM), offering an innovative solution to the global challenge of sustainable pest control.

2. History of entomopathogenic viruses

Although diseases caused by entomopathogenic viruses (EPVs) have been recognized since the 16th century, the causal agents remained unidentified for a long time. It was not until 1524, when Vida studied a disease known as jaundice or grasserie in silkworms (Bombyx mori) in rearing facilities, that the causative agent was later identified as nucleopolyhedroviruses (NPVs). Decades later, between 1950 and 1970, Steinhaus and his collaborators demonstrated the potential of baculoviruses as biological control agents, successfully managing the alfalfa caterpillar using NPV. To date, EPVs have been classified into 13 families out of the 73 known virus families (Szewczyk et al., 2006).

3. Groups of EPVs targeting insects

Baculoviruses:Baculoviruses are key members of entomopathogenic viruses (EPVs), characterized by circular double-

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stranded DNA ranging from 80 to 180 kbp. These rod-shaped viruses are enclosed in an envelope and occluded within polyhedral or granular occlusion bodies (POBs). The International Committee on Taxonomy of Viruses (ICTV) classifies 30 baculovirus species into two genera: Nucleopolyhedrovirus (NPVs) and Granulovirus (GVs). NPVs are further divided into single nucleopolyhedroviruses (SNPVs), containing one virion per envelope, and multiple nucleopolyhedroviruses (MNPVs), which contain multiple virions. Baculoviruses typically have a narrow host range, infecting a single species or closely related species, with the exception of Autographa californica multiple nucleopolyhedrovirus (AcMNPV), which can infect over 30 lepidopteran species (Clem and Passarelli, 2013).

Ascovirus: Ascoviruses possess a circular double-stranded DNA genome ranging from 100 to 180 kbp. The virions in this family are enclosed within an envelope and exhibit bacilliform, allantoid, or ovoid shapes. These virions are occluded within vesicle-like occlusion bodies (OBs). To date, eight species of ascoviruses have been identified, all originating from larvae of eight different noctuid species.

Iridovirus (IV): A defining feature of iridoviruses is the iridescent appearance of infected host tissues, with the color varying depending on the host species. The genome of iridoviruses consists of linear double-stranded DNA, ranging in size from 140 to 303 kb.
Entomopoxvirus:These viruses have a double-stranded DNA genome, ranging in size from 270 to 320 kbp. Their virions exhibit shapes varying from allantoid to brick-like and are enclosed within ovoid occlusion bodies (OBs) known as spheroids.

3. Mode of action: Entomopathogenic viruses (EPVs), such as nucleopolyhedroviruses (NPVs) and granuloviruses (GVs), control insect pests by infecting and killing them through ingestion. When insects consume virus-contaminated material, the occlusion bodies (OBs) dissolve in the alkaline midgut (8-10), releasing enclosed virionsthat infect midgut cells. The virus replicates, spreads to other tissues, and disrupts physiological functions, leading to the death of insects within days (Raj et al., 2022). The insect's body liquefies, releasing new occlusion bodies into the environment, enabling transmission to other hosts. EPVs are highly specific, environmentally safe, and effective against lepidopteran insect pests though their slow action and environmental sensitivity are limitations.

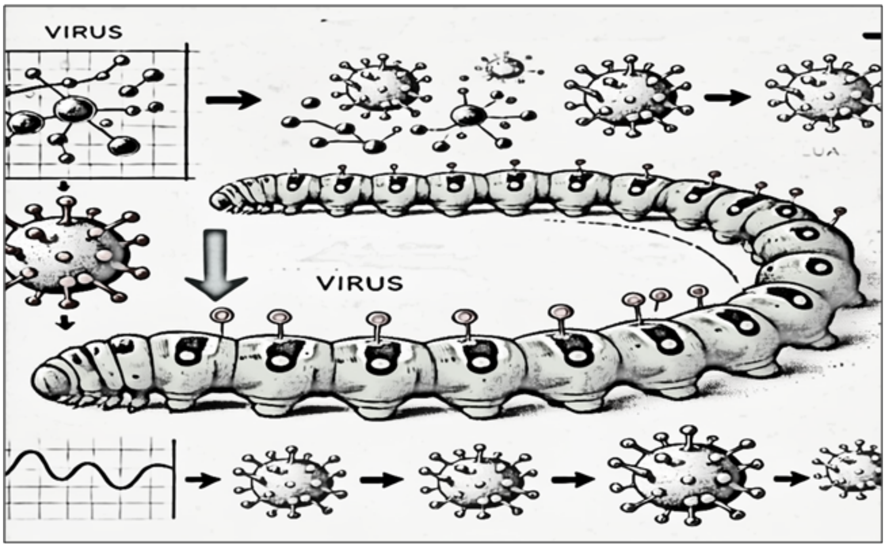

Fig. 1: Entomopathogenic viruses infecting host

4. External symptoms: Insects infected by entomopathogenic viruses specially Nucleopolyhedrovirus (NPVs) and Granulovirus (GVs) often display lethargy, reduced feeding, and altered behavior, such as climbing to elevated positions, a phenomenon called "tree-top disease." This behavior, facilitated by the ecdysteroid UDP-glucosyltransferase (egt) gene, disrupts molting hormone pathways, prolonging infection and enhancing virus spread. As the infection progresses,

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the insect's integument becomes translucent, and it crawls to the tip of plants, hanging upside down in an inverted "V" position from its crochets, likely in search of oxygen (Raj et al., 2022). The body swells, discolors (milky white or dark), and liquefies internally, eventually rupturing to release occlusion bodies, propagating the virus further.

5. Utilization of EPVs for effective pest management

EPVs from almost a dozen viral families have been isolated infecting over 700 insect pests mostly are from Lepidoptera (560), Hymenoptera (100), Coleoptera, Diptera and Orthoptera (40). Among various EPVs reported, the major types of viruses used in pest management are NPVs and GVs for control of pests of vegetables and field crops globally.

(Table 1. Host-Specific Entomopathogenic Viruses (EPVs

Virus Name	Insect pests	Trade products
Autographa californica NPV	*Autographa californica, Hellulaun-.dalis*etc	More, Bitec, Tracer
Helicoverpaarmigera NPV	*Helicoverpaarmigera*	Helicoverpa-NPV, Heli-Get
Spodoptera exigua NPV	*Spodoptera exigua*	,Spod-X, Exile
Cydia pomonella NPV	*Cydia pomonella*	Virosoft, Moth-X
Lymantria dispar NPV	*Lymantria dispar*	GypsyGuard

.**Source:** Murphy & Derksen, 2006

6. Why EPVs are promising agents for biological control?

- EPVs are host-specific, with little to no impact on non-target organisms.
- Serve as natural pest control agents, are safe for the health of the applicator.
- EPVs are environmentally safe, causing no destabilization of ecosystems.
- UV rays degrade occlusion bodies, leaving no harmful residues.
- There have been no reports of pest resurgence or resistance to EPVs.

7. Field application of EPVs

For effective pest control, it is recommended to use 200 mL of NPV per acre or 500 mL per hectare, providing 100 and 250 larval equivalents (LE) of NPV, respectively (1 LE = 6×10^9 polyhedral occlusion bodies or POBs). For high-volume sprayers, dilute 100 mL of NPV in 200–400 L of water, and for power or knapsack sprayers, dilute in 50–70 L of water. Spraying should begin in the evening when newly hatched larvae are observed, with follow-up applications every 7–10 days, depending on pest population levels

8. Genetical modification of EPVs

Genetic modification of entomopathogenic baculoviruses (EPVs) enhances their effectiveness in pest control by increasing virulence and overcoming limitations. For instance, Autographa californicanucleopolyhedrovirus (AcMNPV) has been engineered to express Bacillus thuringiensis (Bt) proteins, improving its lethality against pests like Spodoptera litura and Helicoverpaarmigera. These modifications speed up mortality and expand the virus's host range (Kumar & Zeren, 2018). Additionally, incorporating UV-protectant genes and insect-specific toxins, such as Cry proteins, improves stability and accelerates pest death, making engineered baculoviruses a promising alternative to chemical pesticides.

9. Challenges in Adopting EPVs as Biocontrol Agents

- EPVs need live hosts for reproduction, complicating large-scale production.
- Baculoviruses act slower than chemical insecticides (4–14 days).
- EPVs often can't keep pest populations below economic thresholds.
- Host specificity limits use, but genetic modifications can broaden the range.
- EPVs degrade under UV radiation, using UV protectants help mitigate this.

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10. Conclusion and prospects

Entomopathogenic viruses (EPVs) present a promising approach for managing economically significant insect pests such as H. armigera, A. californica, S. litura, etc. Despite the substantial progress in stabilizing and developing EPV-based biopesticides, challenges such as environmental degradation, species specificity, and difficulties in mass production persist. Recent advancements in insect cell line development for in vitro multiplication and genetic recombination to enhance EPV virulence offer new hope for the industry. Future research should aim to isolate EPVs that target multiple hosts, develop efficient mass production methods at the farm level, create stable formulations for environmental application, and incorporate foreign genes from various organisms to enhance EPV efficacy and field performance.

References:

1. *Clem, R.J., Passarelli, A.L., 2013. Baculoviruses: sophisticated pathogens of insects. PLoSPathog. 9 (11), e1003729.*

2. *Fuxa, J. R., & Tanada, Y. (2023). Entomopathogenic viruses in insect pest management. Springer.*

3. *Kumar, S., & Zeren, S. (2018). Genetic modification of entomopathogenic baculoviruses for improved insect pest control. Journal of Invertebrate Pathology, 153, 47-56.*

4. *Murphy, S. M., & Derksen, R. C. (2006). Biological Control of Insect Pests Using Baculoviruses: Current Status and Future Potential. Advances in Insect Control and Management, 65(5), 279-296.*

5. *Raj, M. N., Samal, I., Paschapur, A., & Subbanna, A. R. N. S. (2022). Entomopathogenic viruses and their potential role in sustainable pest management. In New and Future Developments in Microbial Biotechnology and Bioengineering (pp. 47-72). Elsevier.*

6. *Szewczyk, B., Hoyos-Carvajal, L., Paluszek, M., Skrzecz, I., & Lobo de Souza, M. (2006). Baculoviruses—Re-emerging biopesticides. Biotechnology Advances, 24(2), 143–160.*