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Emergence/Resurgence of Mosquito-borne Diseases and Biological Control Methods

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Introduction

Many causes contribute to the world's enormous relationship between fauna and flora today, including the biggest increase in population growth ever witnessed, complemented by the expansion of transportation infrastructure. These forces break down biogeographic boundaries, resulting in the initial occurrence of species in unfamiliar settings. Invasion of these species is projected to cost more than $120 billion in damage each year in the Americas. Arthropods may spread deadly viruses and parasites and such epidemics and pandemics pose a threat to the world's growing human and animal populations [1].

Mosquitoes (Diptera: Culicidae) are the most harmful vectors because of their role in disease transmission. Key mosquito species are being introduced into new ecosystems as a result of commerce and tourism. A variety of chemical compounds with a good safety profile are commercially accessible, but their toxicity to human skin and the nervous system can cause rashes, swelling and eye discomfort. The most significant disadvantage of these products is the rising occurrence of pesticide resistance in recent years, as well as the exceedingly difficult or simply impossible process of locating and treating all mosquito breeding places. New vector-control strategies and instruments that target aquatic stages and adults are desperately required [2].

Description

Mosquitoes are drawn to people primarily by the lactic acid and CO2 in our perspiration, which are recognised by chemoreceptors in their antennae and repellents hide the human aroma. DEET (N,N-diethyl-meta-toluamide) is the most popular and efficient insect repellent. Biobased mosquito repellents are pest control techniques that use safe, biologically based active components derived from plants, fungus, or bacteria. In areas where endemic mosquito resistance and environmental concerns limit product use, the use of bio-based natural mosquito repellents is preferred to chemical repellents.

DEET (N,N-diethyl-m-toluamide) and IR3535 (3-(NButyl-N-acetyl)-aminopropionic acid are the most effective synthetic repellents. Several nanoparticles that have been synthesised and successfully impregnated into cotton fabrics in insect-repellent clothing show high efficacy against mosquito larvae and adult populations, suggesting that they could be used as eco-friendly approaches to mosquito control if used in long-lasting insect-repellent clothing. Because the use of synthetic repellents produces pesticide resistance in mosquitos, harms non-target creatures and endangers the environment, there has been much debate over this approach of control [3].

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Fungal species from the genera *Lagenidium, Coelomomyces, Entomophthora, Culicinomyces, Beauveria* and *Metarhizium* have received special attention for their ability to reduce mosquito populations, but none of them have been specifically adapted as larvicidal agents against important vector species, including transgenic ones. Application to surfaces where mosquitos land or must pass through, such as fungus-impregnated cloths around bed nets, attractive bait stations, adult mosquito traps and PET traps, yields promising results, with a 39–50 percent reduction in malaria-carrying mosquito survival rates and the elimination of 95 percent of *Anopheles arabiensis* mosquitos in a bait station.

Prior to the discovery of *Bacillus thuringiensis* israelensis (Bti) and *Bacillus sphaericus* (Bs), little attention was devoted to bacteria as sources of agents for microbial control of mosquitoes. Recently, about 1500 microorganisms were identified as potential insecticidal agents and metabolites from approximately a thousand microbial isolates were evaluated for insecticidal action. Bti formulations are the most used nonchemical method for controlling mosquito larvae. Furthermore, multiple studies show that individuals or mixtures of Bti and Bs are extremely efficient and safe for mosquito control and they are regarded harmless to non-target creatures that coexist with mosquito larvae.

IGRs are an excellent method for controlling mosquito populations due to various benefits, including minimal environmental toxicity and selectivity. They are hormone analogues or antagonists that disrupt insect growth. IGR insecticides such as methoprene and pyriproxyfen, two juvenile hormone agonists, are gaining popularity. They are effective against mosquito larvae and may hinder adult emergence; alternative mosquito control agents include novaluron and diflubenzuron. Numerous recent studies have shown that mosquitoes and other pests have evolved resistance to routinely used IGRs such as methoprene and pyriproxyfen, emphasising the need to create novel chemicals and uncover new targets in mosquitoes.

A novel RNAi-based bioinsecticide derived from D-RNA molecules was recently produced and tested on Aedes larval breeding water. The viability of larvae treated with dsRNA was significantly reduced, while the surviving larvae and adults had altered morphology and chitin content. This novel bioinsecticide has insecticidal adjuvant characteristics when combined with diflubenzuron. Another study found that feeding Aedes aegypti adult males double-stranded RNAs (dsRNAs) targeting testis genes reduced their fertility significantly.

These are new technologies aimed to combat mosquito aquatic stages by killing them with sound waves, resulting in immediate death or hindered emergence. They have shown to be an excellent non-chemical solution for the treatment of drinking water sources. When utilised correctly, this method has been demonstrated to be extremely successful in a range of common amounts seen in peri-domestic water containers without creating resistance in mosquito populations or damaging non-target creatures. Furthermore, even basic and inexpensive mobile phones can collect sensitive audio data on the species-specific amount of adult wingbeat noises.

This allows for the simultaneous recording of the time and location of human-mosquito encounters, resulting in a potent tool for acoustically mapping mosquito species distribution globally. Other new acoustic-based techniques for mosquito management during rear-and-release operations have been created, such as the low-cost and battery-powered sound-baited gravid Aedes trap, which may be an effective substitute for the pricey Biogents Sentinel (BGS) trap.

Despite existing approaches, epidemics and the spread of mosquito-borne illnesses persist due to a variety of complicated factors such as pesticide resistance, inadequate control programmes, absent and poorly educated workforce and a lack of financial resources and infrastructure. Many mosquito-borne illness control systems have been developed, each with its own set of strengths and disadvantages. However, systems such as integrated vector management, which use receding horizon control strategies and may take into account numerous objectives, appear to give optimal control solutions that are not only rapid and sustainable, but also offer the most cost-effective control options [4,5].

Conclusion

Improving current tactics, such as the sterile insect technique, the release of insects with dominant lethality, or transgenesis, may give critical answers for averting outbreaks, reducing the risk to at-risk populations and minimising resistance. Meanwhile, promising strategies, such as those mentioned in this publication, have previously demonstrated their usefulness but are underutilised, necessitating increased attention and consideration in vector-control programmes.

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Conflict of Interest

No potential conflict of interest was reported by the authors.

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