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Outsmarting Mosquitoes: Sustainable Strategies for Controlling Disease-Carrying Pests

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ABSTRACT

Historically, mosquitoes have been recognized as important vectors of several serious infectious diseases, representing a major public health concern worldwide. The extensive use of chemical insecticides for mosquito control has contributed to the development and spread of insecticide resistance, thereby reducing the effectiveness of several conventional control measures. This review provides a comprehensive overview of mosquito vectors, the major diseases they transmit, and the principal strategies currently employed for their management. Particular emphasis is placed on recent advances in mosquito control, including environmentally sustainable approaches and emerging technologies aimed at reducing mosquito populations while minimizing adverse effects on ecosystems. The review also identifies important knowledge gaps and highlights key areas requiring further research. These include the influence of climatic and environmental factors on mosquito distribution, population dynamics, and vector competence, as well as the potential application of innovative genetic and molecular approaches, such as RNA interference (RNAi) and the sterile insect technique (SIT). In addition, the potential of biologically based and nature-derived control strategies is discussed as an important component of sustainable mosquito management. Long-term and large-scale surveillance of mosquito populations is also essential for monitoring changes in their distribution, abundance, insecticide resistance, and potential for disease transmission. Therefore, the development of integrated global surveillance systems incorporating advanced monitoring and molecular technologies could facilitate early detection and more effective responses to emerging vector-borne disease risks. Overall, this review emphasizes the need for integrated, evidence-based, and sustainable mosquito management strategies and provides an overview of current knowledge, research gaps, and future priorities for reducing the public health burden associated with mosquito-borne diseases.

1. Introduction

Mosquito-borne diseases represent a major public health threat [1]. Within the Culicidae family, which comprises 3,570 known mosquito species, disease-transmitting varieties like *Aedes*, *Culex*, and *Anopheles* are prevalent [2]. These mosquitoes serve as carriers for a range of detrimental illnesses, including filariasis, Zika virus, yellow fever, dengue fever, chikungunya, West Nile virus, and malaria [1]. The significant proliferation of mosquito populations can not only give rise to formidable health hazards for both humans and animals but also pose substantial impediments to response and recovery efforts [3]. These diseases result in noteworthy mortality rates among livestock and humans on a global scale [4]. In subtropical and

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tropical areas. This problem is rapidly expanding. The Female mosquitoes are among the important insect pests that Mosquitoes act as vectors for the transmission of these viruses [5]. They need a blood meal for egg generation; while feeding, they can transmit several illnesses [1,6]. There are a total of 3,570 known types of mosquitoes in the Culicidae family, which includes disease-carrying species like *Aedes, Culex*, and *Anopheles* [2]. These insects carry various harmful illnesses such as filariasis, Zika virus, yellow fever, dengue fever, chikungunya, West Nile virus, and malaria [1]. The dramatic developments in mosquito populations can provoke difficult health menaces to humans and animals while also becoming serious nuisances that can provide obstacles to response and recovery efforts [3]. These maladies produce significant mortality in livestock and humans worldwide [4]. In subtropical and tropical areas, this problem is very expanding. The Female mosquitoes are among the important insect pests that transport "vectors" this virus [5]. They need a blood meal for egg generation; while feeding, they can transmit several illnesses [6].

Different local agencies have different methods for controlling vectors [7], but they all use Integrated Mosquito Management techniques [8] that focus on targeting both the adult and larval stages at different times. When there are no mosquito-borne diseases in the human population, mosquito control efforts focus on reducing breeding sites and treating water containers that are in use in order to control the mosquito larvae [7]. Reducing the spread of mosquitoes can lessen the future effects of Epidemic mosquito-borne diseases (MBDs). Nonetheless, effectively and reasonably managing mosquitoes poses a challenge [9]. Moreover, methods for controlling mosquitoes vary depending on the specific community and geographical settings.

Synthetic insecticides were commonly used for chemical control due to their quick effectiveness and ease of use. [10,11]. Furthermore, personal protective measures such as repellents are often employed to minimize contact between mosquitoes and humans, thereby reducing the transmission of mosquito-borne diseases [12].

On the contrary, alternative methods for controlling mosquitoes without using chemicals were developed and tested [13,14]. These methods, such as the Integrated Mosquito Management (IMM) program, aim to prevent or reduce outbreaks within a larger ecological and evolutionary context [15,16]. While efforts are being made to discover and implement efficient emergency vector control strategies [17,18], certain plant species containing essential oils have been proven to be effective against various mosquito species at different life stages [19]. Natural insecticides, particularly those derived from plants, show promise in this regard. Mosquito control programs primarily focus on targeting mosquito larvae in their breeding sites using larvicides [20], as they are more susceptible to pest management. Many studies have shown the effectiveness of plant extracts in combating mosquito larvae [21–25]. Additionally, other approaches, like nanoparticles and microbes, have unique characteristics that make them suitable for practical application in the field [1].

The objective of this review has two main parts. Firstly, we will provide a condensed overview of the current research on diseases transmitted by mosquitoes, including their natural history and current status. Secondly, we will pinpoint the most efficient methods for controlling these diseases by utilizing plant extracts and bio-pesticides. The ultimate aim is to establish a framework for generating and monitoring advancements in this field in the future.

2. Mosquito's transmitted diseases

Mosquitoes carry a wide range of dangerous diseases including dengue fever, filariasis, yellow fever, chikungunya, Zika fever, West Nile fever, and malaria [1,26] (Figure 1). These mosquito-borne diseases cause an estimated 2.7 million deaths each year [27], despite efforts to eliminate them through interdisciplinary approaches. Malaria remains a significant global health concern, with 409,000 deaths and 229 million cases reported worldwide in 2019. The

majority of malaria cases and deaths occur in sub-Saharan Africa (WHO. World malaria report 2020. Geneva: World Health Organization; 2020) [28].

The chikungunya virus was found in more than 45 countries, including India where there were 1015 confirmed cases in 2005. Brazil reported its first cases in September 2014, and soon after, it started spreading to various areas. In Brazil alone, there were 63,810 verified cases of chikungunya in 2016 [29].

The virus that causes West Nile fever was first discovered in a person who was infected in Uganda, Africa, in 1937. It was also found to be transmitted occasionally in parts of Europe with more moderate climates, and it is common in tropical areas of Africa, northern Australia, and South Asia. In 1999, the virus reached North America and rapidly spread, becoming a significant public health issue. Since its introduction to the United States, approximately 1.8 million individuals have been infected, leading to 1308 deaths [29]. The earliest reported yellow fever pandemic occurred on the Yucatan Peninsula in 1648. Yellow fever epidemics were documented throughout Central, Latin, North, and South America over the previous two centuries, including both the Atlantic and Pacific coastlines of the United States [30–34]. This disease was seen as a significant threat both in terms of health and its impact on the economy in the United States of America [35–38]. Approximately 20% of individuals affected by yellow fever died, resulting in devastating mortality rates in the Americas due to these epidemics [26,41]. Starting from 2016, the Zika virus has reemerged and become a global threat to the health of the general public. The dengue virus, known for causing hemorrhagic fever and shock syndrome, was considered a significant reemerging infectious disease affecting an estimated 2.5 billion individuals living in areas at risk of infection. Presently, this virus has spread to all nations across the globe, putting approximately 390 million individuals at risk [26,42]. It is predicted that Dengue fever will impact 50-100 million individuals annually on a global scale [43,44]. Females of the mosquito *genus Anopheles* (Diptera: Culicidae) have the ability to transmit six different viral serotypes. [29]

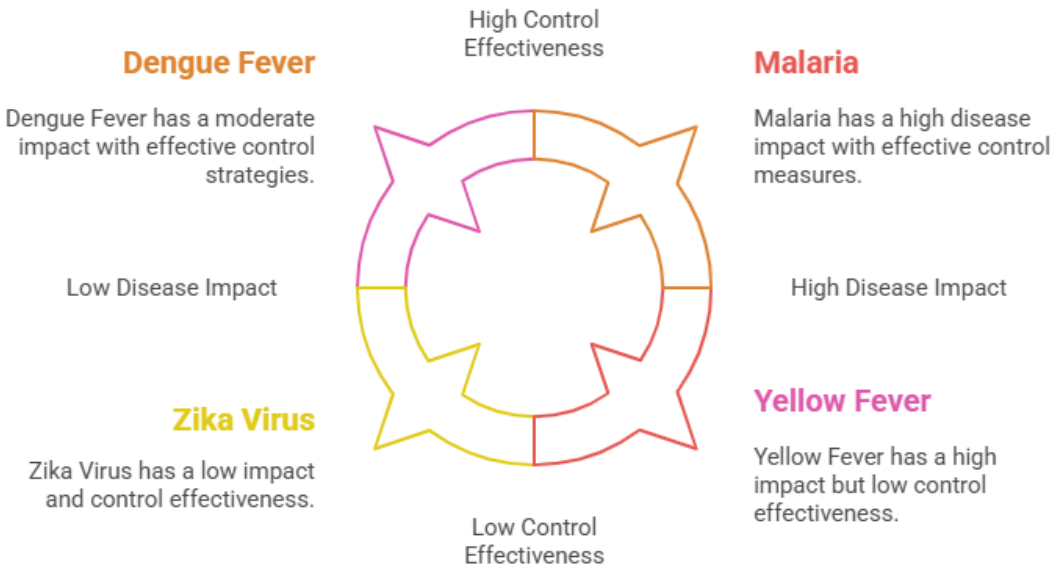

Figure 1: Comparative Analysis of Disease Impact and Control Strategies for Mosquito-Borne Illnesses

3. Current knowledge

3.1 Geographical distribution and climatic conditions1

The compilation and updating of data on the distribution of various species of disease-carrying mosquitoes is extremely important in understanding the potential impact of climate change on the spread of these diseases (Table 1). This data will serve as a foundation for evaluating the relationship between climate factors and the behavior of these mosquitoes. In fact, there is a growing interest within the scientific community in studying the potential health effects of global climate change [45]. Mosquitoes need still water in order to reproduce. Additionally, a warm surrounding temperature plays a crucial role in the feeding habits of adult mosquitoes, the development of larvae, and the speed at which viruses multiply [24,25]. Mosquitoes are able to fly and lay eggs more easily due to the favorable combination of moisture, humidity, warmth, and coolness in the environment [46]. Various non-living elements like increased humidity, phases of the moon, wind, and numerous other factors potentially play a role in the proliferation of mosquitoes belonging to the *Aedes* and *Culex genera*. Aedes mosquito eggs are capable of enduring in moderate environments without water, leading to their easy transmission and hence aiding in the worldwide dispersion of these species [47]. Additionally, there is a possibility of Culex quinquefasciatus being present in surplus environments [48]. Furthermore, there are *Aedes aegypti* mosquitoes that consume human blood [49]. These mosquitoes may be able to survive the cold winter by finding shelter in broken urban concrete tanks [50]. Collecting information about the environment can often be challenging due to various factors such as noise interference and the potential for inaccuracies.

Moreover, various elements such as cloud cover, geography, weather, and temperature have an impact on local environments. It is important to note that the environment is just one among several factors that play a role in determining the levels of mosquito populations [27,51]. The temperature, photoperiod, relative humidity, and the quantity of standing water influence the timing of oviposition [46]. The ability of pregnant mosquitoes to fly, search for a place to lay their eggs, and lay eggs is influenced by physiological factors. One of the factors that affect egg-laying is the nutrition level of the female. Mosquitoes obtain the necessary carbohydrates for flight force through consuming sugar from sources such as nectar, honeydew, or damaged fruit [46].

It is crucial to consider the nutritional state of a mosquito that has consumed blood in order to control the number of eggs it will produce. Feeding on sugar helps in the development and maturation of eggs in both species that can produce eggs without blood feeding and those that require blood for egg development [45,46]. In situations where the climate is too cold, the growth of viruses is limited and mosquitoes are unlikely to survive long enough to spread diseases. However, research and mathematical models predict significant increases in the transmission of diseases carried by vectors under different climate change scenarios [14,52]. Future management and research programs should incorporate this new discovery.

Table 1: Summary of Mosquito-Borne Diseases and Their Impact

Disease	Primary Mosquito Vector	Geographical Distribution	Impact	Key Statistics	Citations
Malaria	*Anopheles* spp.	Sub-Saharan Africa, South Asia, Southeast Asia, South America	Causes severe fever, anemia, and death; significant mortality in children under 5.	229 million cases and 409,000 deaths globally in 2019 (WHO, 2020).	[1], [28]
Dengue Fever	*Aedes aegypti*	Tropical and subtropical regions worldwide	Causes high fever, severe headache, and hemorrhagic fever; can lead to shock syndrome.	390 million people at risk annually; 50-100 million cases reported yearly.	[1], [26], [42]
Zika Virus	*Aedes* spp.	Americas, Africa, Asia, Pacific Islands	Linked to microcephaly in newborns and Guillain-Barré syndrome in adults.	Re-emerged in 2016; global health threat.	[1], [26], [44]

Chikungunya	*Aedes* spp.	Africa, Asia, Europe, Americas	Causes severe joint pain, fever, and rash; rarely fatal but debilitating.	63,810 confirmed cases in Brazil in 2016.	[1], [29]
Yellow Fever	*Aedes* spp.	Africa, South America	Causes jaundice, hemorrhagic fever, and organ failure; high mortality rate.	20% mortality rate in severe cases; historical epidemics in the Americas.	[1], [26], [30-34]
West Nile Virus	*Culex* spp.	Africa, Europe, Middle East, North America, West Asia	Causes fever, headache, and neurological symptoms; can be fatal in severe cases.	1.8 million infections and 1,308 deaths in the U.S. since 1999.	[1], [29]

4. Control and monitoring points

An efficient monitoring system is crucial for effective mosquito control. There are two main types of surveillance in mosquito management: tracking mosquito-borne diseases and monitoring mosquito populations [53]. Mosquito control can reduce the spread of mosquito-borne diseases by decreasing the contact between mosquitoes and humans [54]. Medical and pharmaceutical safety measures such as vaccines and medication might be constrained due to limited resources [54,55] Figure 2. Instantly, the MBDs experience rapid expansion within a few cycles, due to certain female mosquitoes having the capacity to produce hundreds of eggs [56]. Particularly the spread of various products such as used tires, lucky bamboo, and ground transportation worldwide [44]. Furthermore, in the event of eradicating a disease in a specific area, the process of globalization becoming more widespread can introduce new hosts (either human or nonhuman) to that region. Over time, this can lead to the dissemination of the disease within the community (whether human or nonhuman) and eventually lead to its widespread occurrence [27]. The spread of mosquitoes could be influenced by various factors such as a decline in biodiversity, deforestation, urban development, proximity to agricultural areas, increased humidity, and other contributing elements [57,58].

The concept of mosquito control consists of two main aspects: control strategies and control techniques. Mosquito control procedures aim to establish the interconnection among humans, mosquitoes, and the surrounding environment [27]. Control methods consist of insecticide, larvicide, or bug traps. The insecticidal activity of these methods is attributed to a crystal, known as parasporal crystal, that is produced during the stationary phase of the bacteria's growth cycle [33]. There are two different scales of methods: micro-scale, which applies to individuals and neighborhoods, and macro-scale, which applies to cities and territories [27].

The process of collecting data also involves monitoring different stages of the mosquito's life cycle. This includes using ovitraps to collect mosquito eggs, mosquito traps to collect adult mosquitoes, and surveys to study larvae and pupae in their early stages [59].

The majority of mosquito control programs focus on eradicating mosquito larvae in their breeding areas using larvicides [20]. Some people argued for intervening during the adult and egg stages of the insects. The goal is to target the most vulnerable phase while considering the capabilities and characteristics of the detoxifying substance. However, there is a contradiction at this point. The stability of pupae and larvae does not provide a significant advantage because these phases involve long periods of not feeding, which allows the insects to avoid the toxicity of the compounds. Murugan et al. (2012) have demonstrated the effectiveness of orange peel extracts in killing larvae, pupae, repelling, and killing adult mosquitoes of species *A. aegypti*, *A. stephensi*, and *C. quinquefasciatus*. This test reveals the potential for multiple levels of action from the same plant extract. The specific techniques for

each species of mosquito, habitat, and weather will vary, but it is recommended to use a combination of methods for thorough sampling. Ideally, data from surveillance, environment, physical, and spatial sources should be integrated into a geographical information system. This system allows for near-real-time analysis of the data sets and their interactions in a spatial context to guide day-to-day mosquito control operations and evaluate their effectiveness. Furthermore, the use of GIS/GPS technology in surveillance and control processes can enhance performance and precision for better mosquito control [53].

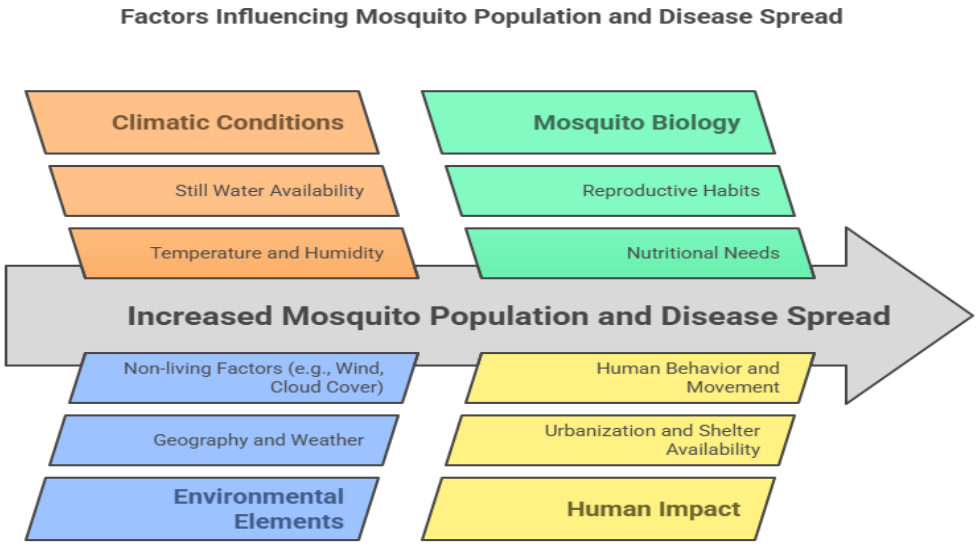

Figure 2: Factors Influencing Mosquito Population and Disease Spread

4.1 Chemical control

In order to control mosquitoes, insecticides can be used at different stages of their development. The immature stages, such as larvae and pupae, can be targeted with larvicides and pupacides, while adult mosquitoes can be controlled with adulticides. Larviciding is considered more effective than adulticiding because the immature forms are easily accessible, cannot move much and cannot escape. Adult mosquitoes, on the other hand, are harder to reach, highly mobile, and often require the use of adulticides over a larger area [53]. Commonly used products for mosquito control include malathion, naled (types of organophosphates), permethrin, resmethrin, and sumithrin (types of synthetic pyrethroids) [60,61]. These chemicals are typically used in low concentrations to minimize their impact on non-target organisms. Adulticides should be used when mosquitoes are active.

Typically, during early night-time hours from 19:00 to 24:00, various species of mosquitoes are active at different times. To ensure effectiveness and minimize the unintended spread of chemicals beyond the intended area, it is important to use them under favorable weather conditions such as no rain, no thermals, and wind speeds below 10 mph. However, relying heavily on chemicals has resulted in several issues, including the development of resistance in multiple mosquito species, negative effects on the environment, and health problems for humans [1,43,62]. Furthermore, the use of chemical insecticides can disrupt the balance between mosquito populations and their natural enemies, causing toxic effects on small mammals in the surrounding area [63,64]. These pesticides are also highly toxic to aquatic life,

non-target aquatic insects, and fish, making it crucial to exercise extreme caution when using them near water. Therefore, reducing the use of chemicals and developing ecological products for mosquito control is important [65,66]. Alternative methods such as biological control and genetic control have been developed, including the use of predatory fishes and fungi, the Bacillus thuringiensis toxin, and Wolbachia-infected mosquito dissemination. However, the long-term effectiveness of these methods still needs to be accurately evaluated [67].

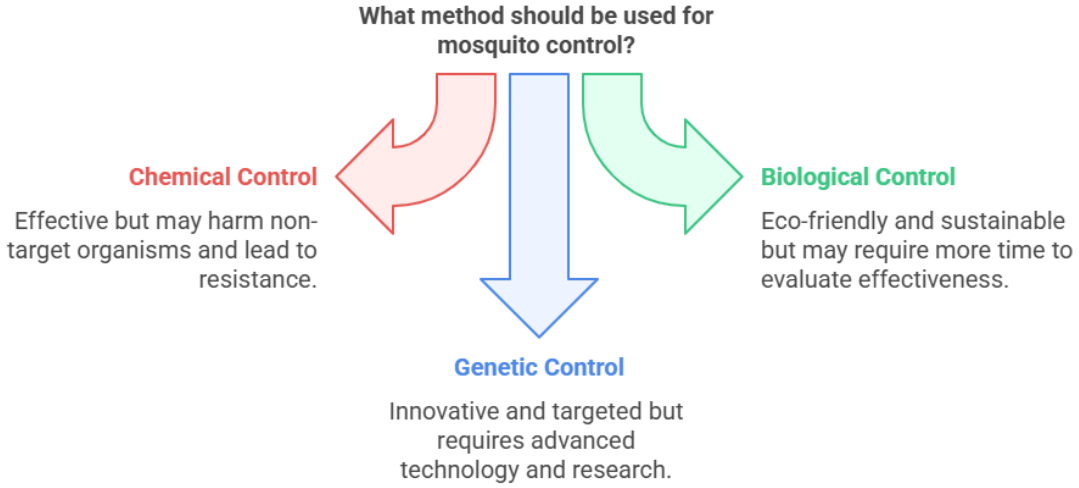

Figure 3: Comparison of Mosquito Control Methods: Chemical, Biological, and Genetic Approaches

Various biological agents have been identified to cause death in mosquitoes, such as oomycetes, algae, bacteria (such as *Bacillus thuringiensis* (Bti), *Lysinibacillus sphaericus*, and genetically modified bacteria), microsporidian and gregarine parasites, pathogenic viruses, nematodes, predatory insects including other mosquitoes, copepods, fish, and other organisms (Figure 3) [53].

Gambusia sp. has been widely introduced in various regions around the world as a means of biological control due to its effective predation on mosquito larvae [68]. However, there are other fish species, identified by Han et al. (2015), that also prey on dengue mosquitoes Aedes spp. larvae. These species include *Tilapia mossambica, Poecilia reticulata, Sarotherodon niloticus, Astyanax fasciatus, Betta splendens, Oreochromis mossambicus, Lepisosteus tropicus, Brycon guatemalensis, Ictalurus meridionalis*, and *Cyprinus carassius*. Laboratory studies have shown that all of these species are effective mosquito predators. Utilizing predator fish alongside other control methods can significantly decrease the infestation of mosquito larvae [69,70].

The mosquito fish Gambusia affinis and G. holbrooki are widely used to control mosquitoes, but their introduction as non-native species can be problematic. It can have severe negative impacts on local ecosystems [53]. Cyclopoid copepods, on the other hand, are organisms that have been found to be highly effective in reducing the population of Aedes mosquitoes [53].

Managing spider populations may offer an extra way to control adult mosquitoes. Ndava et al. (2018) found that certain spider families such as Lycosidae, Tetragnathidae, Trechaleidae, and Pisauridae feed on mosquito larvae, while others from families like Salticidae, Araneidae, Oxyopidae, and Pholcidae prey on flying mosquitoes.

The use of bioactive compounds found in plants and fungi is becoming increasingly important

[71], as they have multiple ways of affecting organisms. Some essential oils have been proven to be effective in killing mosquito larvae and repelling different species of mosquitoes [72]. Plants such as Citrus (Citrus sinensis), Cymbopogon, and Mentha have shown significant toxicity against mosquitoes due to the presence of various metabolites, including aliphatic alcohols and acids, amino acids, alkaloids, and carbohydrates. Additionally, entomopathogenic fungi have been successful in controlling mosquitoes. These bioactive compounds are actively promoting the development of new strategies for mosquito control.

Certain bacterial species have the ability to produce secondary toxins and substances that can cause the death of mosquito larvae. This suggests that when ingested by mosquitoes, symbiotic bacteria might be responsible for causing diseases. Various microorganisms, such as bacteria, protozoa, and fungi, were studied for their insecticide properties. Among them, Bacillus *thuringiensis israelensis* (Bti), *Bacillus sphaericus* (Bs), and related forms are widely used as biolarvicides in controlling mosquitoes and certain species of the Simuliidae family in aquatic environments [73]. Bti, in particular, has shown excellent potential as a fly control agent due to its ability to infect and kill insects. The World Health Organization suggests the use of biolarvicides derived from Bti and *Bacillus sphaericus* (also known as *Lysinibacillus sphaericus*) to combat mosquito larval populations. These biolarvicides were considered environmentally friendly alternatives. Currently, *Bacillus thuringiensis* var. israelensis is the most commonly used mosquito larvicide in European countries [33]. Moreover, it does not pose any risks to humans or other organisms that are not the intended target [74,75].

Xenorhabdus and *Photorhabdus* are naturally occurring substances that can be used as mosquito-killing agents for both larvae and adults [73]. In particular, the fabclavines family found in *Xenorhabdus innexi* can quickly kill larvae of *Aedes aegypti*, *Anopheles gambiae*, and Culex pipiens, as well as adult *A. aegypti* mosquitoes.

Xenorhabdus fabclavines are a promising new group of mosquito control substances, according to Kajla (2020). Bacterial types from the *Xenorhabdus* and *Photorhabdus* genera have proven to be effective in controlling mosquitoes. Approximately 5 species of *Photorhabdus* and 24 species of *Xenorhabdus* were identified as having insecticidal properties.

Furthermore, a variety of *Xenorhabdus* and *Photorhabdus* species displayed insecticidal effects on mosquitoes, as observed in a study conducted by Da Silva et al. (2020) [29]. Specifically, Ae. aegypti larvae were provided with *Photorhabdus luminescens* and *X. nematophila* as their food source. Within 24 hours, half of the larvae had perished, with the mortality rate reaching 100% after 96 hours.

Fungi known as *Lagenidium, Coelomomyces,* and *Culicinomyces* were found to have an impact on mosquito populations. One specific aquatic species called L. giganteum Couch was extensively studied and is considered a potential commercial mosquito control agent. The authors proposed adding *Leptolegnia caudata* to *Anopheles culicifacies*, which led to a complete eradication of larvae after 7 days and reduced the transmission of malaria [76].

Leptolegnia chapmanii, it is a dangerous pathogen of larvae and adult of A. aegypti (L.), which suffer 100% mortality within 24 hrs after exposure. [77]. *Leptolegnia* spp. accessible to culture in vitro [76]. *L. giganteum* was provoked large mortalities in mosquitos in many laboratories, in the short and large-scale field (California and North Carolina), particularly in Culex [78–81], and Anopheles species [80]; seven essential oils (*Cinnamomum microphyllum, Cinnamomum mollissimum, Cinnamomum rhyncophyllum, Auxemma glazioviana, Callitris glaucophylla*, *Zanthoxylum oxyphyllum*, and *Blumea densiflora*) showed LC50 < 10 ppm [82], highlighting the encouraging potential of these essential oils for the expansion of more innovative and efficient control tools [75].

Several studies have proposed the use of plant-based composites to rapidly and effectively synthesize metal nanoparticles [83]. These nanoparticles have been found to have strong mosquitocidal properties, even in real-life field conditions [23,62,84]. Numerous studies have highlighted the effectiveness of plant-fabricated metal nanoparticles in killing mosquitoes, with over 100 studies specifically emphasizing their potent mosquitocidal toxicity [84]. From an entomological perspective, these green nanoparticles have successfully reduced mosquito populations in the field, as well as prevented the hatching of mosquito eggs [85]. In addition, invertebrates such as earthworms ware also utilized to produce silver nanoparticles that are highly effective against malaria-carrying mosquitoes in their early life stages [86]. Reducing the amount of plants can have a significant impact on the number of mosquitoes in an area.

4.2 Piege trap

The Gravid traps and oviposition traps were created to take advantage of mosquito oviposition behavior. The successful use of these traps for monitoring mosquito populations led to the idea that they could also be effective for controlling vector-borne diseases [46]. Gravid traps are particularly important for virus surveillance because they capture females that have already laid eggs and are more likely to be carrying pathogens obtained through blood feeding [46]. Ovitraps, on the other hand, contain attractants that indicate the types of mosquitoes present in a specific area. They were used to study both the eggs and adults of Culex and Aedes mosquitoes. For instance, a modified ovitrap with a special adhesive on the interior wall was just as successful as a standard ovitrap in detecting Ae. aegypti mosquitoes [46]. Lethal ovitraps, which were used in "attract-and-kill" strategies, have been successfully used to control Ae. aegypti in Australia, where public support for this trapping program was crucial. Experiments in Australia have shown that lethal ovitraps treated with the chemical bifenthrin, a type of pyrethroid, were repellent to gravid Ae. aegypti mosquitoes. This suggests that these traps have the potential to provide additional control measures for Ae. aegypti in integrated vector control programs.

4.3 Genitic control

The Chitin, which is a polymer made of N-acetylglucosamine, plays a crucial role in forming important external barriers that protect insects and help them survive in their surroundings. These barriers include the exoskeleton (cuticle), the peritrophic matrix (PM) in the intestine, and the eggshell. Chitin plays important roles in all stages of a mosquito's life, making it a suitable target for control (Table2) [87]. Chitin, a substance that can be consciously controlled, plays a key role in the synthesis of chitin synthases A and B (CHs). RNA interference (RNAi) is a method used to specifically reduce the production of target proteins, and it was utilized in the creation of a potential bioinsecticide for controlling mosquitos. In this study, dsRNA molecules were generated in both laboratory settings and living organisms by expressing them in E. coli HT115. These dsRNA molecules targeted five different regions in the transcript sequences of Chitin synthases A and B. The effects of these dsRNA molecules were then analyzed by adding them to the breeding water of mosquito larvae. The results showed that the larvae treated with dsRNA exhibited significantly reduced viability, which can be attributed to a decrease in the transcript levels of Chitin synthases A and B [67,88]

Furthermore, the bioproduct, which was based on lysates of recombinant E. coli expressing dsRNA, produced a high mortality proportion, even in 4th-instar larva, which was connected with a drop in CHSA and B transcripts and, as a result, lower chitin concentration in the PM and cuticle. Additionally, this method was shown to use an insecticidal effect [67,89].

Ribonucleic acid interference (RNAi) represents a reversed genetic technique that was recently developed as a novel pest management strategy. Concerning the mosquito. Many different gaming strategies were used to induce RNAi in mosquito larvae [1]. In order to cause

mosquito death, Mysore et al.53 employed Saccharomyces cerevisiae yeast that interfered with RNA larvicides targeting brain genes. This approach showed important results.

Recently, ribonucleic acid interference (RNAi)-based reverse genetic searches have emerged as a crucial tool for analyzing the roles of genes [90,91]. The main performance program for RNAi in mosquitoes was direct injection into the body cavity, with an emphasis on the adult stage. Numerous studies shown the benefits of RNA interference (RNAi) in silencing genes linked to various physiological processes in various organs across a wide range of mosquito species [92–95]. Newly, RNAi in mosquito larvae was registered development in the downregulation of a number of target genes. Molecular techniques like qRT-PCR and phenotypic changes like mortality were used to demonstrate this downregulation [96]. The researchers created genetically engineered male Aedes aegypti with a gene that restricts wing growth. This gene spread to the progeny, preventing them from being able to fly after mating with females [44]

4.5 The method of sterile insects (SIT)

The sterile insect technique (SIT) assays applied DNA-damaging factors (γ-radiation) to produce lethal alterations (25) produce sterile males. For example, a nuclease is expressed in the male germline to create malformed chromosomes (82), Release of insects carrying a dominant lethal genetic system (RIDL; 2, 65, 74) gives important results [97]

The result is an extreme decrease in the target population [66]. The benefit of this control technique is principally associated with the competition capability of the sterile males over natural males [75].

In Italy Release of irradiated males, Aedes albopictus produced sterility in target populations; population elimination was observed in some locations [97]

In the Cayman Islands, the dispersal of males mosquitoes harboring a dominant lethal gene (RIDL) strain of Aedes aegypti, OX513A, led to effective suppression of the target wild population [97].

Furthermore, new discoveries show that Wolbachia bacteria-based techniques might be expanded as a potential strategy of controlling Aedes aegypti [13,44]. Accumulating confirmation has proved that the mosquito transcriptome profiles were changed after Wolbachia infection [98]. New researches have recommended that Wolbachia bacteria suppress virus replication [98].The insect immune pathways such as IMD, Toll, and JAK/STAT pathways were activated in Wolbachia-infected Ae. aegypti, and led to an adequate decrease in replication of DENV, CHIKV, and Plasmodium. Non-coding of mosquitos Wolbachia infection affects RNA expression, which may govern viral replication in infected cells [98].

The application of cytoplasmic incompatibility (CI) may represent an effective mosquito control approach [65,66], especially for Aedes control. CI may be produced by the bacterium Wolbachia [65,66]. The CI showed as embryonic death following mating between Wolbachia-contaminated males and Wolbachia-free females (suppression) or females infected with diverse Wolbachia strains (replacement). The combination of sterile insect technique and incompatible insect technique (IIT), based on cytoplasmic incompatibility can be a prosperous tool for mosquito control.(Arunachalam and Curtis, 1985; Brelsfoard et al., 2009; Calvitti et al., 2015).

In general, the use of Wolbachia is an encouraging mechanism for mosquito control single or combined with SIT [15,84]. Another novel approach for mosquito control relied on transgenic methods. Within this mechanism is available to include novel genes in the genome of different mosquito vector species, utilizing transposable components [65]. This approach may be utilised for population suppression [99].

Table 2: Comparison of Mosquito Control Methods

Control Method	Description	Advantages	Disadvantages	Examples	Citations
Chemical Control	Use of synthetic insecticides to kill mosquitoes at different life stages.	Quick and effective; easy to apply.	Resistance development; environmental and health risks; non-target organism toxicity.	Malathion, permethrin, resmethrin.	[10], [11], [60], [61]
Biological Control	Use of natural predators, pathogens, or parasites to control mosquito populations.	Environmentally friendly; sustainable; targets specific species.	May require time to establish; effectiveness varies by species and environment.	Gambusia fish, Bacillus thuringiensis, predatory copepods.	[53], [68], [69], [73]
Genetic Control	Genetic modification or sterilization of mosquitoes to reduce populations.	Highly argeted; potential for long-term population suppression.	Ethical concerns; requiresextensive research and testing; public acceptance challenges.	Sterile Insect Technique (SIT), Wolbachia-infected mosquitoes, RNA interference (RNAi).	[13], [44], [65], [66], [97]
Natural Repellents	Use of plant-based extracts or essential oils to repel or kill mosquitoes.	Eco-friendly; low toxicity to humans and non-target species.	Variable effectiveness; may require frequent application.	Citronella, neem oil, eucalyptus oil.	[19], [21-25], [72]
Integrated Management	Combination of multiple control methods to manage mosquito populations sustainably.	Comprehensive approach; reduces reliance on single methods; adaptable to local conditions.	Requires coordination and resources; complex implementation.	Combination of chemical, biological, and environmental management strategies.	[8], [15], [16], [53]

5. Additional Requirements

Health education and a modification of human behavior [74]. The application of insecticides, a decrease in possible breeding localities, and growing public health knowledge has thus far not been capable reduce the reestablished population [44,87]. Coordinating research efforts among countries, organisations, laboratories and institutions was recommended to reach the crucial objective of controlling the transmission of mosquito-borne diseases.

Although a scientific monitoring network focused on hotspot points such as tropical zones in Africa and Asia was needed to ensure a systematic observation and treatment. Setting up such scientific monitoring scheme in these areas would benefit not just the mosquito-borne diseases but also other vector diseases (e.g. trypanosoma disease, malaria and recent Ebola virus). Comprehensive data on distribution, abundance, habitats, predators, food supplies and climatic impacts will be advantageous to implement an effective management strategy, in order to protect local and destination countries.

The data included geography sources, Aerial imagery, climate sources, remote sensor data and environmental sources [14], socioeconomic factors and landscape factors [100] are also valuable data sources [101]. Additionally, there other factors interesting to know in order to set up an appropriate integrated pest management method, the most common considered in the reviewed papers included temperature, humidity, elevation, landcover, poverty, and population density [102].

References

1. Munawar, K.; Alahmed, A.M.; Khalil, S.M.S. Delivery methods for RNAi in mosquito larvae. J. Insect Sci. 2020, 20, 1–8, doi:10.1093/jisesa/ieaa074.

2. Reidenbach, K.R.; Cook, S.; Bertone, M.A.; Harbach, R.E.; Wiegmann, B.M.; Besansky, N.J. Phylogenetic analysis and temporal diversification of mosquitoes (Diptera: Culicidae) based on nuclear genes and morphology. BMC Evol. Biol. 2009, 9, 1–14, doi:10.1186/1471-2148-9-298.
3. CLARK, M.S.; ROGERS, A.N. Florida department of agriculture and consumer services mosquito control incident response team: An exercise in using the national incident management system's incident command system for disaster response. J. Am. Mosq. Control Assoc. 2020, 36, 35–40, doi:10.2987/19-6886S.1.
4. Wilder-Smith, A.; Chen, L.H.; Massad, E.; Wilson, M.E. Threat of dengue to blood safety in dengue-endemic countries. Emerg. Infect. Dis. 2009, 15, 8–11, doi:10.3201/eid1501.071097.
5. Bansal, N.K.; Mathur, R.; Bhandari, M.S. A study of solar chimney assisted wind tower system for natural ventilation in buildings. Build. Environ. 1994, 29, 495–500, doi:10.1016/0360-1323(94)90008-6.
6. Gouge, A.; Holt, J.; Hardy, A.P.; Sowden, J.C.; Smith, H.K. Foxn4 - A new member of the forkhead gene family is expressed in the retina. Mech. Dev. 2001, 107, 203–206, doi:10.1016/S0925-4773(01)00465-8.
7. Schwab, S.R.; Stone, C.M.; Fonseca, D.M.; Fefferman, N.H. The importance of being urgent: The impact of surveillance target and scale on mosquito-borne disease control. Epidemics 2018, 23, 55–63, doi:10.1016/j.epidem.2017.12.004.
8. Rose, R.I. Pesticides and public health: Integrated methods of mosquito management. Emerg. Infect. Dis. 2001, 7, 17–23, doi:10.3201/eid0701.010103.
9. van Lenteren, J.C.; Bolckmans, K.; Köhl, J.; Ravensberg, W.J.; Urbaneja, A. Biological control using invertebrates and microorganisms: plenty of new opportunities. BioControl 2018, 63, 39–59, doi:10.1007/s10526-017-9801-4.
10. Hwang, Y.S.; Wu, K.H.; Kumamoto, J.; Axelrod, H.; Mulla, M.S. Isolation and identification of mosquito repellents in Artemisia vulgaris. J. Chem. Ecol. 1985, 11, 1297–1306, doi:10.1007/BF01024117.
11. Tripathi, A.K.; Mishra, S. Plant Monoterpenoids (Prospective Pesticides); Elsevier Inc., 2016; ISBN 9780128032664.
12. Pitasawat, B.; Choochote, W.; Tuetun, B.; Tippawangkosol, P.; Kanjanapothi, D.; Jilpakdi, A.; Riyong, D. Repellency of aromatic turmeric Curcuma aromatica under laboratory and field conditions. J. Vector Ecol. 2003, 28, 234–23440.
13. Hoffmann, A.A.; Montgomery, B.L.; Popovici, J.; Iturbe-Ormaetxe, I.; Johnson, P.H.; Muzzi, F.; Greenfield, M.; Durkan, M.; Leong, Y.S.; Dong, Y.; et al. Successful establishment of Wolbachia in Aedes populations to suppress dengue transmission. Nature 2011, 476, 454–459, doi:10.1038/nature10356.
14. Ramzi, A.; El, A.; Lalami, O.; Ez, Y.; Assouguem, A.; Almeer, R.; Najda, A.; Ullah, R.; Ercisli, S.; Farah, A. Insecticidal Effect of Wild-Grown Mentha pulegium and Rosmarinus officinalis Essential Oils and Their Main Monoterpenes against Culex pipiens (Diptera: Culicidae). Plants 2022, 1–12.
15. Yakob, L.; Funk, S.; Camacho, A.; Brady, O.; Edmunds, W.J. Aedes aegypti Control Through Modernized, Integrated Vector Management. PLoS Curr. 2017, 9, doi:10.1371/currents.outbreaks.45deb8e03a438c4d088afb4fafae8747.
16. Agusto, F.B.; Bewick, S.; Parshad, R.D. Mosquito management in the face of natural selection. Math. Biosci. 2012, 239, 154–168, doi:10.1016/j.mbs.2012.05.001.
17. Unlu, I.; Rochlin, I.; Suman, D.S.; Wang, Y.; Chandel, K.; Gaugler, R. Large-Scale Operational Pyriproxyfen Autodissemination Deployment to Suppress the Immature Asian Tiger Mosquito (Diptera: Culicidae) Populations., doi:10.1093/jme/tjaa011.
18. Gaff, H.D.; White, A.; Leas, K.; Kelman, P.; Squire, J.C.; Livingston, D.L.; Sullivan, G.A.; Baker, E.W.; Sonenshine, D.E. TickBot: A novel robotic device for controlling tick populations in the natural environment. Ticks Tick. Borne. Dis. 2015, 6, 146–151, doi:10.1016/j.ttbdis.2014.11.004.
19. Mansour, M.A.; Connick, W.B.; Lachicotte, R.J.; Gysling, H.J.; Eisenberg, R. Linear Chain Au(I) Dimer Compounds as Environmental Sensors: A Luminescent Switch for the Detection of Volatile Organic Compounds. J. Am. Chem. Soc. 1998, 120, 1329–1330, doi:10.1021/ja973216i.
20. Knio, K.M.; Usta, J.; Dagher, S.; Zournajian, H.; Kreydiyyeh, S. Larvicidal activity of essential oils extracted from commonly used herbs in Lebanon against the seaside mosquito, Ochlerotatus caspius. Bioresour. Technol. 2008, 99, 763–768, doi:10.1016/j.biortech.2007.01.026.
21. Kalyanasundaram, M.; Das, P.K. Larvicidal & synergestic activity of plant extracts for mosquito control. Indian J. Med. Res. 1985, 82, 19–23.
22. Govindarajan, M.; Jebanesan, A.; Pushpanathan, T.; Samidurai, K. Studies on effect of Acalypha indica L. (Euphorbiaceae) leaf extracts on the malarial vector, Anopheles stephensi Liston (Diptera:Culicidae). Parasitol. Res. 2008, 103, 691–695, doi:10.1007/s00436-008-1032-2.
23. Kovendan, K.; Murugan, K. Effect of medicinal plants on the mosquito vectors from the different agroclimatic regions of Tamil Nadu, India. Adv. Environ. Biol. 2011, 5, 335–344.
24. Kovendan, K.; Murugan, K.; Vincent, S.; Kamalakannan, S. Larvicidal efficacy of Jatropha curcas and bacterial insecticide, Bacillus thuringiensis, against lymphatic filarial vector, Culex quinquefasciatus Say (Diptera: Culicidae). Parasitol. Res. 2011, 109, 1251–1257, doi:10.1007/s00436-011-2368-6.
25. Kovendan, K.; Murugan, K.; Vincent, S.; Barnard, D.R. Studies on larvicidal and pupicidal activity of Leucas aspera Willd. (Lamiaceae) and bacterial insecticide, Bacillus sphaericus, against malarial vector, Anopheles stephensi Liston. (Diptera: Culicidae).

Parasitol. Res. 2012, 110, 195–203, doi:10.1007/s00436-011-2469-2.
26. Gubler, D.J. The changing epidemiology of yellow fever and dengue, 1900 to 2003: Full circle? Comp. Immunol. Microbiol. Infect. Dis. 2004, 27, 319–330, doi:10.1016/j.cimid.2004.03.013.
27. Joshi, A.; Miller, C. Review of machine learning techniques for mosquito control in urban environments. Ecol. Inform. 2021, 61, 101241, doi:10.1016/j.ecoinf.2021.101241.
28. Oria, P.A.; Moshi, V.; Odero, J.I.; Ekodir, S.; Monroe, A.; Harvey, S.A.; Ochomo, E.; Black, D.P. A retail audit of mosquito control products in Busia County, western Kenya. Malar J 2021, 20, 163, doi:10.1186/s12936-021-03695-1.
29. Da Silva, W.J.; Pilz-Júnior, H.L.; Heermann, R.; Da Silva, O.S. The great potential of entomopathogenic bacteria Xenorhabdus and Photorhabdus for mosquito control: a review. Parasites and Vectors 2020, 13, 1–14, doi:10.1186/s13071-020-04236-6.
30. Kramrisch, S. Artibus Asiae Publishers. Artibus Asiae 1953, 11, 1-3+5-47+49-51.
31. Reiter, P.; Amador, M.A.; Colon, N. Enhancement of the CDC ovitrap with hay infusions for daily monitoring of Aedes aegypti populations. J. Am. Mosq. Control Assoc. 1991, 7, 52–55.
32. Ponnusamy, L.; Xu, N.; Nojima, S.; Wesson, D.M.; Schal, C.; Apperson, C.S. Identification of bacteria and bacteria-associated chemical cues that mediate oviposition site preferences by Aedes aegypti; 2008;
33. Lacey, L.A. Microbial Control of Medically Important Mosquitoes in Tropical Climates. In Microbial Control of Insect and Mite Pests: From Theory to Practice; Elsevier Inc., 2017; pp. 409–430 ISBN 9780128035665.
34. Gould, D.J.; Moralejo, D.; Drey, N.; Chudleigh, J.H.; Taljaard, M. Interventions to improve hand hygiene compliance in patient care. Cochrane Database Syst. Rev. 2017, 2017.
35. Perry, fay and MN_V25_N3_P276-281.pdf.
36. WILLIAMS, L.L. Pesticides: a Contribution To Public Health. Am. J. Public Health Nations. Health 1964, 54, doi:10.2105/ajph.54.suppl_1.32.
37. Schliessmann, D.J. Initiation of the Aedes aegypti eradication programme of the USA. Bull. World Health Organ. 1967, 36, 604–609.
38. Patterson, K.D. Yellow fever epidemics and mortality in the United States, 1693-1905. Soc. Sci. Med. 1992, 34, 855–865, doi:10.1016/0277-9536(92)90255-O.
39. Sedaratian, A.; Fathipour, Y.; Moharramipour, S. Comparative life table analysis of Tetranychus urticae (Acari: Tetranychidae) on 14 soybean genotypes. Insect Sci. 2011, 18, 541–553, doi:10.1111/j.1744-7917.2010.01379.x.
40. SCHLIESSMAN; DJ A review of the status of yellow fever and Aedes aegypti eradication programs in the Americans. Mosq. News 1974, 34, 1–9.
41. Monath, T.P. Yellow fever and dengue-The interactions of virus, vector and host in the re-emergence of epidemic disease. Semin. Virol. 1994, 5, 133–145, doi:10.1006/smvy.1994.1014.
42. Franco, J.C.; Suma, P.; Da Silva, E.B.; Blumberg, D.; Mendel, Z. Management strategies of mealybug pests of citrus in mediterranean countries. Phytoparasitica 2004, 32, 507–522, doi:10.1007/BF02980445.
43. Paupy, C.; Delatte, H.; Bagny, L.; Corbel, V.; Fontenille, D. Aedes albopictus, an arbovirus vector: From the darkness to the light. Microbes Infect. 2009, 11, 1177–1185, doi:10.1016/j.micinf.2009.05.005.
44. Medlock, J.M.; Hansford, K.M.; Schaffner, F.; Versteirt, V.; Hendrickx, G.; Zeller, H.; Bortel, W. Van A review of the invasive mosquitoes in Europe: Ecology, public health risks, and control options. Vector-Borne Zoonotic Dis. 2012, 12, 435–447, doi:10.1089/vbz.2011.0814.
45. Blum, A.J.; Hotez, P.J. Global "worming": Climate change and its projected general impact on human helminth infections. PLoS Negl. Trop. Dis. 2018, 12.
46. Day, J.F. Mosquito oviposition behavior and vector control. Insects 2016, 7, doi:10.3390/insects7040065.
47. Cunze, S.; Koch, L.K.; Kochmann, J.; Klimpel, S. Aedes albopictus and Aedes japonicus - two invasive mosquito species with different temperature niches in Europe. Parasites and Vectors 2016, 9, 1–12, doi:10.1186/s13071-016-1853-2.
48. Wong, G.K.L.; Jim, C.Y. Urban-microclimate effect on vector mosquito abundance of tropical green roofs. Build. Environ. 2017, 112, 63–76, doi:10.1016/j.buildenv.2016.11.028.
49. Harrington, L.C.; Buonaccorsi, J.P.; Edman, J.D.; Costero, A.; Kittayapong, P.; Clark, G.G.; Scott, T.W. Analysis of survival of young and old Aedes aegypti (Diptera: Culicidae) from Puerto Rico and Thailand. J. Med. Entomol. 2001, 38, 537–547, doi:10.1603/0022-2585-38.4.537.
50. Nguyen-Tien, T.; Lundkvist, Å.; Lindahl, J. Urban transmission of mosquito-borne flaviviruses–a review of the risk for humans in Vietnam. Infect. Ecol. Epidemiol. 2019, 9, doi:10.1080/20008686.2019.1660129.
51. Rund, S.S.C.; Moise, I.K.; Beier, J.C.; Martinez, M.E. Rescuing Troves of Hidden Ecological Data to Tackle Emerging Mosquito-Borne Diseases. J. Am. Mosq. Control Assoc. 2019, 35, 75–83, doi:10.2987/18-6781.1.
52. Blum, A.J.; Hotez, P.J. Global "worming": Climate change and its projected general impact on human helminth infections. PLoS Negl. Trop. Dis. 2018, 12, 8–13, doi:10.1371/journal.pntd.0006370.
53. Rey, J.R.; Walton, W.E.; Wolfe, R.J.; Roxanne, C.; O'Connell, S.M.; Berg, J.; Sakolsky-Hoopes, G.E.; Laderman, A.D. North American wetlands and mosquito control. Int. J. Environ. Res. Public Health 2012, 9, 4537–4605, doi:10.3390/ijerph9124537.
54. Sallam, M.F.; Xue, R. De; Pereira, R.M.; Koehler, P.G. Ecological niche modeling of mosquito

vectors of West Nile virus in St. John's County, Florida, USA. Parasites and Vectors 2016, 9, 1–14, doi:10.1186/s13071-016-1646-7.
55. Wongsrichanalai, C.; Pickard, A.L.; Wernsdorfer, W.H.; Meshnick, S.R. Epidemiology of drug-resistant malaria. Lancet Infect. Dis. 2002, 2, 209–218.
56. Subramanian, S.; Shankarganesh, K. Insect Hormones (As Pesticides); 2016; ISBN 9780128032664.
57. Burkett-Cadena, N.D.; Vittor, A.Y. Deforestation and vector-borne disease: Forest conversion favors important mosquito vectors of human pathogens. Basic Appl. Ecol. 2018, 26, 101–110, doi:10.1016/j.baae.2017.09.012.
58. Manguin, S.; Boëte, C. Manguin and Boëte 2011 Global impact of mosq biodiversity-environmt change.pdf. 2001.
59. Arista-Jalife, A.; Nakano, M.; Garcia-Nonoal, Z.; Robles-Camarillo, D.; Perez-Meana, H.; Arista-Viveros, H.A. Aedes mosquito detection in its larval stage using deep neural networks. Knowledge-Based Syst. 2020, 189, 104841, doi:10.1016/j.knosys.2019.07.012.
60. Ramkumar, G.; Karthi, S.; Muthusamy, R.; Natarajan, D.; Shivakumar, M.S. Insecticidal and repellent activity of Clausena dentata (Rutaceae) plant extracts against Aedes aegypti and Culex quinquefasciatus mosquitoes (Diptera: Culicidae). Parasitol. Res. 2015, 114, 1139–1144, doi:10.1007/s00436-014-4288-8.
61. Benelli, G. Research in mosquito control: current challenges for a brighter future. Parasitol. Res. 2015, 114, 2801–2805.
62. Vivekanandhan, P.; Venkatesan, R.; Ramkumar, G.; Karthi, S.; Senthil-Nathan, S.; Subramanian Shivakumar, M. Comparative Analysis of Major Mosquito Vectors Response to Seed-Derived Essential Oil and Seed Pod-Derived Extract from Acacia nilotica. 2018, doi:10.3390/ijerph15020388.
63. Török, E.; Hochkirch, A.; Soltész, Z.; Tscharntke, T.; Batáry, P. Unmeasured side effects of mosquito control on biodiversity. Eur. J. Entomol. 2020, 6.1, 71–76.
64. Schwab, S.R.; Stone, C.M.; Fonseca, D.M.; Fefferman, N.H. The importance of being urgent: The impact of surveillance target and scale on mosquito-borne disease control. Epidemics 2018, 23, 55–63, doi:10.1016/j.epidem.2017.12.004.
65. Papanicolaou, A.; Schetelig, M.F.; Arensburger, P.; Atkinson, P.W.; Benoit, J.B.; Bourtzis, K.; Castañera, P.; Cavanaugh, J.P.; Chao, H.; Childers, C.; et al. The whole genome sequence of the Mediterranean fruit fly, Ceratitis capitata (Wiedemann), reveals insights into the biology and adaptive evolution of a highly invasive pest species. Genome Biol. 2016, 17, 1–31, doi:10.1186/s13059-016-1049-2.
66. Bourtzis, K.; Lees, R.S.; Hendrichs, J.; Vreysen, M.J.B. More than one rabbit out of the hat: Radiation, transgenic and symbiont-based approaches for sustainable management of mosquito and tsetse fly populations. Acta Trop. 2016, 157, 115–130, doi:10.1016/j.actatropica.2016.01.009.
67. Lopez, B.G.; Guimarães-Ribeiro, V.; Victor, J.; Rodriguez, G.; Dorand, F.A.P.S.; Salles, T.S.; Sá-Guimarães, T.E.; Alvarenga, E.S.L.; Claudia, A.; Melo, A.; et al. RNAi-based bioinsecticide for Aedes mosquito control. 2019, doi:10.1038/s41598-019-39666-5.
68. Huancahuari, M.; Pensati, F.; Rongoni, A.; Carrieri, M.; Bellini, R. The introduction of Gambusia holbrooki in rice field for mosquito control can positively affect rice production. Bull. Insectology 2016, 69, 131–141.
69. Tian, H.Y.; Bi, P.; Cazelles, B.; Zhou, S.; Huang, S.Q.; Yang, J.; Pei, Y.; Wu, X.X.; Fu, S.H.; Tong, S.L.; et al. How environmental conditions impact mosquito ecology and Japanese encephalitis: An eco-epidemiological approach. Environ. Int. 2015, 79, 17–24, doi:10.1016/j.envint.2015.03.002.
70. Benelli, G.; Romano, D. Mosquito vectors of Zika virus. Entomol. Gen. 2017, 36, 309–318, doi:10.1127/entomologia/2017/0496.
71. Srivastava, H.M.; Jankov, D.; Pogány, T.K.; Saxena, R.K. Two-sided inequalities for the extended Hurwitz-Lerch Zeta function. Comput. Math. with Appl. 2011, 62, 516–522, doi:10.1016/j.camwa.2011.05.035.
72. Mansour, S.A.; El-Sharkawy, A.Z.; Abdel-Hamid, N.A. Toxicity of essential plant oils, in comparison with conventional insecticides, against the desert locust, Schistocerca gregaria (Forskål). Ind. Crops Prod. 2015, 63, 92–99, doi:10.1016/j.indcrop.2014.10.038.
73. Kajla, M.K. Symbiotic Bacteria as Potential Agents for Mosquito Control. Trends Parasitol. 2020, 36, 4–7, doi:10.1016/j.pt.2019.07.003.
74. Jansen, C.C.; Beebe, N.W. The dengue vector Aedes aegypti: what comes next. Microbes Infect. 2010, 12, 272–279, doi:10.1016/j.micinf.2009.12.011.
75. Benelli, G.; Caselli, A.; Canale, A. Nanoparticles for mosquito control: Challenges and constraints Nanoparticles for mosquito control. J. King Saud Univ. - Sci. 2017, 29, 424–435, doi:10.1016/j.jksus.2016.08.006.
76. Scholte, E.J.; Knols, B.G.J.; Samson, R.A.; Takken, W. Entomopathogenic fungi for mosquito control: A review. J. Insect Sci. 2004, 4, doi:10.1093/jis/4.1.19.
77. Boyce, W.M.; Lawler, S.P.; Schultz, J.M.; McCauley, S.J.; Kimsey, L.S.; Niemela, M.K.; Nielsen, C.F.; Reisen, W.K. Nontarget effects of the mosquito adulticide pyrethrin applied aerially during a West Nile virus outbreak in an urban California environment. J. Am. Mosq. Control Assoc. 2007, 23, 335–339, doi:10.2987/8756-971X(2007)23[335:NEOTMA]2.0.CO;2.
78. Nunes, M.A.; Novelli, V.M.; da Cunha, B.A.; Soares, A.J.; de Mineiro, J.L.C.; Freitas-Astúa, J.; Bastianel, M. Survey of the citrus leprosis vector (Brevipalpus yothersi) and phytoseiids in spontaneous plants of an organic citrus orchard. Exp. Appl. Acarol. 2020, 82, 199–209, doi:10.1007/s10493-020-00543-w.

79. Jaronski, S.T. Ecological factors in the inundative use of fungal entomopathogens. BioControl 2010, 55, 159–185, doi:10.1007/s10526-009-9248-3.
80. Karungu, S.; Atoni, E.; Ogalo, J.; Mwaliko, C.; Agwanda, B.; Yuan, Z.; Hu, X. Mosquitoes of etiological concern in Kenya and possible control strategies. Insects 2019, 10, 1–23, doi:10.3390/insects10060173.
81. Iparraguirre, M.. Particularidades biológicas de Parlatoria ziziphi (Lucas) en los cítricos de Ciego de Ávila y sus enemigos naturales. Available online: https://agris.fao.org/agris-search/search.do?recordID=CU2006102074 (accessed on Aug 20, 2022).
82. Pavela, R.; Stepanycheva, E.; Shchenikova, A.; Chermenskaya, T.; Petrova, M. Essential oils as prospective fumigants against Tetranychus urticae Koch. Ind. Crops Prod. 2016, 94, 755–761, doi:10.1016/J.INDCROP.2016.09.050.
83. Nazeer, A.A.; Rajan, H.V.; Vijaykumar, S.D.; Saravanan, M. Evaluation of Larvicidal and Repellent Activity of Nanocrystal Emulsion Synthesized from F. glomerata and Neem Oil Against Mosquitoes. J. Clust. Sci. 2019 306 2019, 30, 1649–1661, doi:10.1007/S10876-019-01611-X.
84. Benelli, G.; Mehlhorn, H. Declining malaria, rising of dengue and Zika virus: insights for mosquito vector control. Parasitol. Res. 2016, 115, 1747–1754, doi:10.1007/s00436-016-4971-z.
85. Calvitti, M.; Marini, F.; Desiderio, A.; Puggioli, A.; Moretti, R. Wolbachia Density and Cytoplasmic Incompatibility in Aedes albopictus: Concerns with Using Artificial Wolbachia Infection as a Vector Suppression Tool. 2015, doi:10.1371/journal.pone.0121813.
86. Jaganathan, A.; Murugan, K.; Panneerselvam, C.; Madhiyazhagan, P.; Dinesh, D.; Vadivalagan, C.; Aziz, A.T.; Chandramohan, B.; Suresh, U.; Rajaganesh, R.; et al. Earthworm-mediated synthesis of silver nanoparticles: A potent tool against hepatocellular carcinoma, Plasmodium falciparum parasites and malaria mosquitoes. Parasitol. Int. 2016, 65, 276–284, doi:10.1016/J.PARINT.2016.02.003.
87. sheila Barbara G. Lopez1, Victor Guimarães-Ribeiro1, João Victor G. Rodriguez1, Fernando A. p. s. Dorand1, tiago s. salles1, thayane e. sá-Guimarães1, evelyn s. L. Alvarenga1, Ana Claudia A. Melo1, 2, Rodrigo V. Almeida 1 & Monica F. Moreira 1, 2 RNAi-based bioinsecticide for Aedes mosquito control _ Enhanced Reader.pdf 2019.
88. Wu, G.A.; Terol, J.; Ibanez, V.; López-García, A.; Pérez-Román, E.; Borredá, C.; Domingo, C.; Tadeo, F.R.; Carbonell-Caballero, J.; Alonso, R.; et al. Genomics of the origin and evolution of Citrus. Nature 2018, 554, 311–316, doi:10.1038/nature25447.
89. Mesquita, R.D.; Vionette-Amaral, R.J.; Lowenberger, C.; Rivera-Pomar, R.; Monteiro, F.A.; Minx, P.; Spieth, J.; Carvalho, A.B.; Panzera, F.; Lawson, D.; et al. Erratum: Genome of Rhodnius prolixus, an insect vector of Chagas disease, reveals unique adaptations to hematophagy and parasite infection (Proceedings of the National Academy of Sciences of the United States of America (2015) 112 (14936-14941) DOI 10.107. Proc. Natl. Acad. Sci. U. S. A. 2016, 113, E1415–E1416, doi:10.1073/pnas.1600205113.
90. Lateur, M. Perspectives de lutte contre les maladies des arbres fruitiers à pépins au moyen de substances naturelles inductrices d'une résistance systémique. Biotechnol. Agron. Soc. Environ. 2002, 6, 67–77.
91. F. Rehman, M. Kalsoom, M.A. Huanglongbing (HLB) As Citrus Devastating Disease: A Technical Report. SunText Rev. Biotechnol. 2020, 01, 2–4, doi:10.51737/2766-5097.2020.013.
92. Drake, L.L.; Rodriguez, S.D.; Hansen, I.A. Functional characterization of aquaporins and aquaglyceroporins of the yellow fever mosquito, Aedes aegypti., doi:10.1038/srep07795.
93. Mohammed, K.; Karaca, İ.; Agarwal, M.; Newman, J.; Ren, Y. Age-specific life tables of aonidiella aurantii (Maskell) (hemiptera: Diaspididae) and its parasitoid aphytis melinus debach (hymenoptera: Aphelinidae). Turkish J. Agric. For. 2020, 44, 180–188, doi:10.3906/tar-1905-36.
94. Park, J.; Kim, D.I.; Choi, B.; Kang, W.; Kwon, H.W. Classification and Morphological Analysis of Vector Mosquitoes using Deep Convolutional Neural Networks. Sci. Reports 2020 101 2020, 10, 1–12, doi:10.1038/s41598-020-57875-1.
95. Wu, A.; March, L.; Zheng, X.; Huang, J.; Wang, X.; Zhao, J.; M.Blyth, F.; Smith, E.; Buchbinder, R.; Hoy, D. Enhanced Reader.pdf. Nature 2020, 388, 1–14.
96. Airs, P.M.; Bartholomay, L.C. RNA interference for mosquito and mosquito-borne disease control. Insects 2017, 8, doi:10.3390/insects8010004.
97. Alphey, L. Genetic control of mosquitoes. Annu. Rev. Entomol. 2014, 59, 205–224, doi:10.1146/annurev-ento-011613-162002.
98. Yen, P.S.; Failloux, A.B. A review: Wolbachia-based population replacement for mosquito control shares common points with genetically modified control approaches. Pathogens 2020, 9, 1–14, doi:10.3390/pathogens9050404.
99. Blandin, S.; Moita, L.F.; Köcher, T.; Wilm, M.; Kafatos, F.C.; Levashina, E.A. Reverse genetics in the mosquito Anopheles gambiae: targeted disruption of the Defensin gene. EMBO Rep. 2002, 3, 852–856, doi:10.1093/EMBO-REPORTS/KVF180.
100. Li, R.; Xu, L.; Bjørnstad, O.N.; Liu, K.; Song, T.; Chen, A.; Xu, B.; Liu, Q.; Stenseth, N.C. Climate-driven variation in mosquito density predicts the spatiotemporal dynamics of dengue. Proc. Natl. Acad. Sci. U. S. A. 2019, 116, 3624–3629, doi:10.1073/pnas.1806094116.
101. Xiaoling Pan, Andrew Pike, Deepak Joshi, Guowu Bian, Michael J McFadden,Peng Lu, Xiao Liang, Fengrui Zhang, A.S.R.Z.X. The bacterium Wolbachiaexploits host innateimmunity to establish a symbiotic relationship withthe dengue vector mosquitoAedes aegypti. 2018.
102. Wieland, R.; Kerkow, A.; Früh, L.; Kampen, H.; Walther, D. Automated feature selection for a machine

learning approach toward modeling a mosquito distribution. Ecol. Modell. 2017, 352, 108–112, doi:10.1016/J.ECOLMODEL.2017.02.029.