



## International Journal of Mosquito Research

ISSN: 2348-5906

CODEN: IJMRK2

IJMR 2022; 9(6): 22-26

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Received: 10-09-2022

Accepted: 12-10-2022

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## A review on multifaceted approaches for effective control of mosquitoes: From conventional and biological to phytochemical methods

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DOI: <https://doi.org/10.22271/23487941.2022.v9.i6a.636>

### Abstract

The continuous spreading of mosquitoes is affecting human health and causing viral and protozoan diseases. The seasonal or perennial appearance known as re-emergence of vector borne diseases are the key for facing of life dangerous diseases and global public health. Among these vector borne diseases; the mosquito borne diseases sharing major part in human health consequences. The mosquitoes are transmitting diseases in more than 700 million human annually. Therefore, it is imperative to deliver the effective management techniques of mosquitoes to the society and make them aware; thereby the mosquitoes borne diseases can be reduced significantly. In the present review report authors summarised most of the conventional and biological methods along with the most important eco-friendly and phytochemical or plant derived mosquito repellent methods. The mosquito repellents are chemical products which either facilitates the killing of mosquitoes directly or make them senseless thereby ceasing their physiological activities. There are several plant derived compounds known to contain repellent properties and can be employed as defence against mosquitoes. These plant derived compounds contain toxins, growth regulators, phenolic, nitrogen compounds and terpenoids, which are bitter in taste and act as effective anti-mosquito agents or mosquito repellents and profoundly helpful in the management of variety of mosquito borne diseases.

**Keywords:** Mosquitoes, mosquito repellent, phytochemicals, mosquito control, mosquito borne diseases

### Introduction

A significant source of illness or death worldwide continues due to transmission of insect diseases. The vector borne diseases play a vital role on human health as well as animals [1-4]. Annually approximately 700 million peoples in World are affected by mosquito and vector borne diseases [5]. Mosquitoes are the member of phylum Arthropoda; class Insecta, and order is Diptera [6]. The Mosquito means "little fly" in Spanish and kills about 3 million people in each year by most common mosquito borne protozoan diseases Malaria [7]. Approximately one and all has unpleasant experience of being bitten by a mosquito and cause skin irritation through an allergic reaction and local red patches around bitten area due to itching [8-9]. Approximately 2 billion peoples face risk of many mosquito vector borne diseases in tropical countries such like as fever, dengue, malaria, leishmaniasis and filariasis [10-11]. Firstly think about how to control mosquitoes and their vector borne diseases and secondly effective vaccinations against dangerous diseases which are keeping being developed, to control from mosquitoes and protection of human from their bites is most important method to manage these diseases. Utilizing of repellents is a clear cut practical method and cost-effective way to stop the spread of these diseases to people [12-14]. Repellents are good source, economical and beneficial for human to prevent transmission of mosquito diseases [15-18]. Herbal plants based repellents are still widely used in a conventional manner in rural tropical culture in a traditional way [19-22].

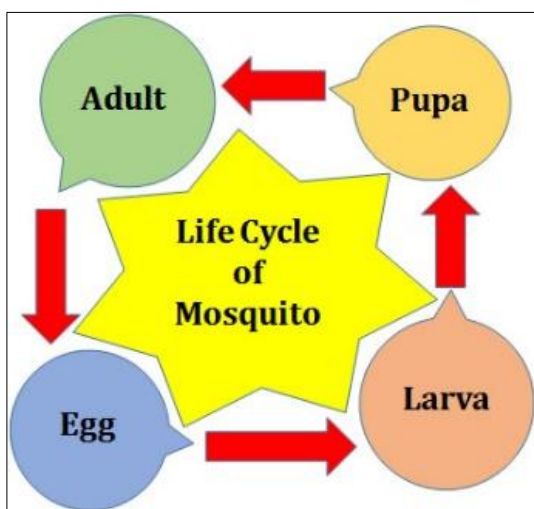


Fig 1: Life cycle of mosquito.

More than 3000 species of mosquitoes present in whole world and include 39 genera and 153 subgenera [23-25]. Bates [26] was the pioneer mosquito biologist who explored the life cycle of mosquito (Fig. 1) and defined common terms of life cycle policies. However, Pratt [27] identified many of the problems with findings and reports of Bates [26] and represents a different of classification scheme that was limited to mosquitoes in North America. According to classification of Pratt's three main biological traits of mosquitoes are (i) first stage is mosquitoes overwinter (ii) second is egg-laying location, (iii), generation per year. The most common known mosquitoes are the *Anopheles*, *Aedes*, *Culex*, *Culiseta*, *Mansonia*, *Psorophora*, *Toxorhynchites*, *Wyeomyia*, etc. and each has their specific characteristics and potential to several diseases [3-4, 9, 28].

## 2. Multifaceted Approaches for Effective Control of Mosquitoes

### 2.1 Biochemical strategies

The National Diseases Control using insecticides which play a vital role to control vectors. NMEP is a programmes which control both filariasis and leishmaniasis vector borne diseases. NVBDCP directorate is main department which prevent and control the vector borne disease across India. India using several insecticides which are synthetic in nature such like as DDT (organochlorines), malathion (organophosphate), some pyrethroid and aerial spraying which are safe for human health [29].

### 2.2 Biological control

Biological control is the application of natural agents to control the population of mosquitoes by hitting the mosquitoes life cycle. These bio-control agents such like as bacteria, fungi, algae viruses, and nematodes, may affect the life stages of mosquitoes or mosquitoes larval stage by entry through their natural pores [29].

#### a. Entomopathogenic fungi

Entomopathogenic fungi play a vital role against malarial vectors to control and management of malarial vectors. *Coelomomyces*, *Culicinomyces*, *Entomophthora* and *Lagenidium* genera of fungi are used as purpose against malarial vectors [30]. Fungal spores are employed curtains, cotton items, indoor houses services and outdoor traps as a

mosquito repellent [31]. DDT and fungus widely used together against mosquitoes as insecticide susceptible as well as insecticidal resistance to mosquitoes. If compare to insecticide, *Anopheles gambelii* is more vulnerable to fungal infection and rate is slow as comparable insecticide [32]. According to reports, use of *metarhizium* repel mosquitoes and inhibit speed and production of anti-malarial peptides [33]. Pathogenic fungi have high impact on *Anopheles* mosquito to affect their life cycle [34].

#### b. Larvivorous fish

Application of predatory fish is an ancient method which used to control the mosquitoes larval stage. *Gambusia affinis* which belongs to cyprinodontide and mostly used to control larval stage of the mosquitoes. Use of larvivorous fish is more effective as compare to chemical methods [35].

### 2.3 Physical methods

Physical methods apply against mosquitoes by changing standing water of birds, pools, birds bath, rain water and fountains water, which are causing agent to produce mosquitoes. Screenings to door protect from mosquitoes attack [36].

- a. **Mosquito net:** Mosquitoes nets are protected from mosquitoes because they are made of polyester or nylon which helps to restrict entry of mosquitoes. These nets are not harmful for human health and no chemical added. Nets are two types medicated as well as non-medicated [37].
  - i. **Medicated net:** Medicated nets made up of 25% deltamethrin which made by K-O tablets. One tablet is properly mixes in one litter water for ten minutes and after it dried and placed at chilled area to make medicated nets [38]. Medicated nets life only six months, which is approved by WHO [39].
  - ii. **Non-medicated net:** Non medicated nets have launched according their shape and size, and made up of different material such like as polyester, cotton as well as nylon. Style also matter because net pore fine or wide depend on mosquitoes shape [40]. Very important things to by a non-medicated net it contain large size and air passes completely and protect from mosquitoes [41].
- b. **Mosquito traps:** Mosquitoes trap are widely used to attract and capture female mosquitoes. These traps mimic the numerous mosquitoes to attract own side to produce body heat and carbon dioxide from exhalation. Most or mosquitoes trap made of electrical such like as racket type which help to attract and stick mosquitoes and burn them [42]. Mechanical device widely used as mosquito traps which act as magnet and electric production in these devices [43].
  - i. **Electric mosquito zipper:** Electric zippers containing ultraviolet lights which buran to mosquitoes when it sticks at surface of zipper and a lethal charge produced via zipper to kill mosquitoes [44].
  - ii. **Mosquito magnet:** The idea behind it's to mimic mammals and device to release of heat, moistures and carbon dioxide. When mosquitoes come to across magnet, they suddenly die after attraction. Sand flies, black flies and mosquitoes controlled with the help of magnet [44].

### 3. Mosquito repellents and Phytochemicals

The organic compounds also used as mosquitoes repellent by providing the uncomfortable surface or unattractive to mosquitoes. These repellents are organic material forms in nature and synthesis or artificial *in vitro* to make surface repulsive to insects, animal and plants [45]. Typically, these have primary ingredient which help to keep away mosquitoes, and other compounds that help to cosmetic appeal [46]. Ethnomedicinal methods help to repel mosquitoes such like as smoking, plant extract, tars, citronell oil [19, 22, 47]. Due to abundant of terpenes, the oil of *Ocimum basilicum* and *Ocimum gratissimum* has high capacity to repel mosquitoes as traditional methods [48]. A material found to be valuable against mosquito if it can deter mosquitoes; attack on the treated area for few hours, on a variety of different surfaces according to environmental conditions. Mosquitoes repellents should be eco-friendly in nature when these applied on human skin or animals and also cosmetically acceptable with pleasing odour and taste. Additionally should be safe as well as low costly and effective against flies, mosquitoes and insects [49]. These are formed in many varieties such like as cream, forms, and oils, but typically supplied as aerosols form [50]. Repellency played a vital role in recognition of vector borne diseases to minimise man and vector contacts. An ideal repellent is non-toxic, odourless, non-irritating and non-grassy in nature which protecting transmission of diseases, blood-feeding arthropods approximately eight hours [51]. Mainly repellents are created using chemical substances which have unpleasant taste and smell mosquitoes. Herbal plants derived compounds defend against insects which act as defence mechanisms and pose a threat to plants. Based on the functional groups present; many chemicals such as nitrogen, terpenoids, phenolic compounds which act as inhibitors as well as growth regulators. These compounds help to fight against insects. Plants hold up a lot of promise to provide compounds which creating power to anti-mosquitoes products [52-56]. The majority of plants have substances that they use to protect themselves from phytophagous (plant-eating) insects, which include repellents, feeding deterrents, poisons, and growth regulators. When leaves are damaged, plants frequently release volatile compounds known as "green leaf volatiles" to fend off herbivores. However, because to their great vapour toxicity to insects, many plant volatiles are most likely deterrents or repellent. Numerous instances exist in India where plants, in whole or in part (dried or fresh and in various forms, including leaf, fruit, seed, and root), have been used for thousands of years. The most common methods involve hanging bruised plants in homes or burning them in fire after preparing them with animal dung (neem leaves are the best example of a natural repellent) [57-58].

### 4. Acknowledgements

We greatly acknowledge Maharishi Markandeshwar (Deemed to be University) Mullana-Ambala (Haryana), India for providing the requisite platform to write this article.

### 5. Conflict of Interest

Authors declare that there is no conflict of interest pertaining to publication of this manuscript.

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