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Traditional Wisdom in Modern Vector Control: Ayurvedic Approaches Against Mosquitoes

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Abstract
Mosquitos are very annoying and cause several harmful diseases to humans and animals. Pathogens are transferred by the mosquito and cause malaria, dengue, Chikungunya, filariasis, Japanese encephalitis etc. In avoidance of mosquito-borne diseases, mosquito repellents like Synthetic, plant-based, and biological types of repellents are used. Traditionally, N,N-diethyl-meta-toluamide (DEET) synthetic repellent is commercially used, and many other synthetic repellents are available, but these may cause toxicity like undesirable odor, neurological, sub-chronic toxicity to humans and also affect environmental conditions. Because of this reason, humans towards the plant-based mosquito repellent products where essential oils of plants target the mosquito neurosystem by inhibiting cellular respiration and potassium –sodium exchange. Plant-based products have no side effects, are eco-friendly and cost-effective. This review article aims to provide details on methods that are used to control mosquitos, especially plant-based mosquito repellents.

Key Words: Mosquitos, malaria, dengue, Chikungunya, filariasis, Japanese encephalitis.

Introduction

Mosquitoes are important as transmitters of disease like dengue, lymphatic filariasis, malaria, haemorrhagic, Japanese encephalitis etc. 80% of global population is affected by mosquito borne diseases pose a significant risk to more than and making them primary contributors to the burden to human vector borne diseases. To reduce such problems, humans are using various mosquito repellents compounds. [1] [2] Repellents are the tools which reduce the contact between mosquitos and their host and in many instances, it decrease the transmission of disease. N,N –diethyl-3-methylbenz amide (DEET), is commercially used as synthetic mosquito repellent but the some safety reports suggest that it cause toxicity. Long term use of DEET shows undesirable effects like mutagenicity, reproductive, undesirable odor, neurological and sub-chronic toxicity.Sumithrin, sumithrin, malathion and resmethrin are other synthetic pyrethriods involve in mosquito control program by killing adult mosquitoes. From the safety point of view most the people move towards the plant based mosquito repellent as it has no side effect on humans. Plant essential oil is complex, naturally occurring substance with strong smell which discomfort the mosquitos.[3]

Mosquito

Mosquito are annoying and most disturbing bloodsucking insects. Many diseases, including Dengue fever, malaria, yellow fever, and others, are spread by mosquito species from the Anopheles, Culex, and Aedes genera. Because the antibodies IgG and IgE attach to one of the antigens. Immune reaction triggers when the mosquito releases its saliva into the host's blood. Redness, Itching, Irritations, and rarely pimples are the results of the reactions.[4]

Classification of mosquito

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Subclass: Pterygota
Order: Diptera
Suborder: Nematocera
Family: Culicidae
Subfamily: Culicinae[5]

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Figure 1: Mosquito

Life Cycle of mosquito

Mosquito life cycle is divided into 4 phases and each phase is easily predictable by its special appearance.

Egg: Single egg is laid at a time or together to form rafts. On the water's surface, they float. The eggs of Culex are adhered to one another in rafts of up to 200. Many genera, including Anopheles and Aedes, lay their eggs singly rather than in egg rafts. On the surface of water Culex and Anopheles lay their eggs. Aedes type of genera lay their eggs on damp soil that will be flooded with water. Maximum eggs hatch into larvae within 48 hr. Before hatching, others were able to endure the winter of sub-zero. Water play essential role in their habitat.

Larvae: Larvae survives in the water and comes to the upper part of water to breathe. About 4 times larvae shed their skins and grow larger after each molt. Larvae breathes with the help of siphon tubes which they have and hang upside down from the water surface. Anopheles larvae don't have siphon tubes, therefore they lie parallel on the surface of water to breathe. To get air supply Mansonia larvae is attach to the plants. In water larvae feed microorganisms and organic matter. Larva changes into a pupa during the 4th molt.

Pupa: This stage is non-feeding and resting, but pupae is movable, move with a flip of tails towards the protecting areas. In this stage mosquito changes into an adult. After completion of development, the pupils skin ruptures and the adult mosquito emerges

Adult: Developed adult mosquito rest on the water's surface for some time to permit itself to dry and all its body parts to harden. Before flying the wings have to spread out and dry properly. Blood feeding and mating occur after some days when the adult mosquito emerges.[6]

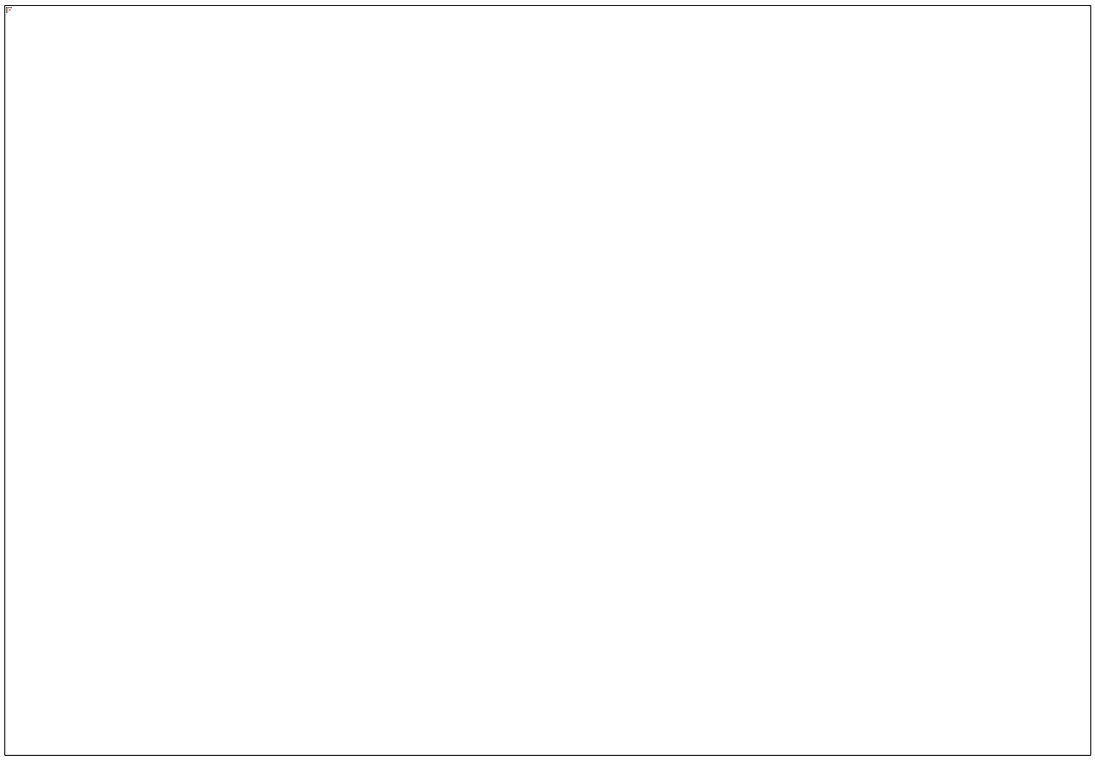

Figure 2: Life cycle of Mosquitos[7]

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Mosqutio borne disease

Because of bite of infected female mosquitoes Mosquito-borne diseases are spreads. The main mosquito-borne diseases comprise Dengue, Zika, malaria, Chikungunya, West Nile, yellow fever, Rift Valley fever, tick-borne encephalitis and Lymphatic filariasis.

a. **Malaraia:** Caused by the infected female Anopheles mosquitoes and create life-threatening conditions in an individual.
b. **West Nile:** Caused by the West Nile virus which is an enclosed, positive-strand ribonucleic acid (RNA) flavivirus of the family Flaviviridae. The virus affects birds, humans, dogs, horses and other animals.
c. **Dengue:** Caused by a positive (+)-stranded ribonucleic acid (RNA) virus. Transmission of virus occur through the bite of infected female Aedes albopictus and Ae. aegypti and zoonotic agents. Morbidity and mortality rate is increases due to this disease.
d. **Yellow fever disease:** Produced by the yellow fever virus. In non-human primates yellow fever can cause epizootics.
e. **Rift Valley fever:** It is a disease of domestic livestock like sheep, cattle and goats, as well as humans. Transmission of disease occur by mosquitos or direct contact with infected animals.
f. **Lymphatic filariasis:** Lymphatic filariasis (LF) is caused by microfilaria of Brugia malayi or or Brugia timori, Wuchereria bancrofti. Most of the population is affected by it.[8]

Ayurvedic management of mosquito bite

Through ayurvedic drugs insect bites can be treated including mosquito bites. Ayurvedic classics provide information regarding treatment of mosquito bites according to their symptoms and sign. This comprises internal and external application of Agadayogas(anti toxic formulations)

a. Application of Paste (External)

- Make a paste of black ant soil by using cow urine.
- Paste of flower of Ocimum sanctum linn.
- Wash the site of insect bites with buttermilk.
- Paste of lime juice with ammonium chloride is applied externally in case of severe pain.

b. Fumigation Method

Fumigation is known as dhoopana in ayurvedic text and it was believed to relieve symptoms and provide complete treatment against mosquito bites. By Acharya Kashyapa, Nrikeshadi dhoopa is prepared which a fumigation combination which consist yellow mustard, human hair and old jaggery, indicated for fumigating the site of mosquito bite, to decrease the uneasiness caused by the mosquito bite.

Other Examples:

a. Seeds of Bhallathakaand Arka, Gokshura, Musta and Sarjarasa, Maricha.
b. Aparajitha dhooma have proven microcidam activity.[9]

Table: 1 Plant based Mosquito repellent

Cymbopogon nardus (Citronella)	Due to its antifungal properties, citronella oil is also used to treat insect bites.
Eucalyptus globulus	Eucalyptus essential oil used as an antiseptic, insect repellent and treatment option for wounds.[10]
Lemon grass	Lemon grass have properties because of which it is be potentially used for the preparation of mosquito repellent products. Available in different dosage forms and it could be prepared using suitable carries/solvents/diluents, to get better protection from mosquito bites. And help in reducing the harmful effects of synthetic mosquito repellents on human health.[11]
Azadirachta indica	According to published research, neem works incredibly well to keep mosquitoes away. This is because of the substance Azadirachthin, which irritates the mosquito's mucous membranes and is employed as an antifeedant (it prevents the insect from eating and unable to consume human blood meal).
Cinnamommum camphora	It has been used for generations as a successful ant and mosquito repellant.
Styrax genus.	From styrax genus, benzoin a natural resin is obtained. Its odour repels mosquitoes. For decades, in India, China etc. benzoin is used as mosquito repellent.[12]
Lavandula genus	Linalool and linalyl acetate present in lavender as an active constituents, which exhibit insect-repelling properties. As a natural insect repellent, lavender oil is popular choice because of its calming effects and pleasant aroma.

Basil	Essential oils extracted from basil have demonstrated significant repellent activity against various mosquito species.
Rosmarinus officinalis	Rosemary essential oil contains compounds such as camphor and 1,8-cineole, which have shown repellent activity against mosquitoes. Incorporating rosemary oil into repellent formulations may offer a natural and eco-friendly alternative to synthetic insecticides
Citrus spp.	Citrus species is rich in essential oils containing compounds such as limonene and citral, which exhibit insect-repelling properties. Its citrusy aroma and repellent activity make orange peel a potential candidate for inclusion in natural insect repellents.
Santalum album	Essential oils extracted from sandalwood contain compounds such as santalol, which possess insect-repelling properties. Clove essential oil contains eugenol, a compound known for its insecticidal and repellent properties.
Thymus spp.	Essential oils extracted from thyme contain thymol and carvacrol, compounds known for their insect-repelling and insecticidal properties.[13]
Corymbia citriodora	Lemon eucalyptus extract was determined to have mosquito-repelling properties.
Pelargonium reniforme	Extract of pelargonium is found to be active against mosquito bites High pungent odour is released form this plant. And after research it was found that it was effective as mosquito repellent.
Ocimum spp	Species of this genus contain active constituents like linoleic acid, linalool, linalool, eugenol, citral, estragosol, eucalyptol, thujone, ocimene, p-cymene, camphor and many other which make it responsible to act as repellents.
Tagetes species	Monoterpeniods esters present in tagetes species and they possess insecticidal and larvicidal properties.
Lippiaspp	**L. cheraliera:** Tradiutionally the leaves of L. cheraliera is used as mosquito repellents. **L. javanica:** Infusion of leaves of L. javanica found to be used in variety of ailments. Strong lemon smell of leaves shows its healing properties.
Vitex negundo (indian privet)	Leaves contained terpinines, terpeneol, and sesquiterpene alcohols which shows effective mosquito repellent. [14]
Acanthospermum hispidum	A. hispidum contain essential constituents that are capable of inhibiting the transmission of merozoites, the disease-causing infectious agents, into the host's bloodstream. Have good antimalarial activities.
Physalis angulat	Plant leaf comprises anti-malarial, anti-inflammatory, antioxidant properties.[15]
Semecarpus anacardium	Plant shows the occurrence of terpeniods and steroids these groups may be responsible for larvicidam activity. Paste of this plant is also applied to treat mosquito bites.
Syzygium cumin	Known as jamun. Conatin active constituents and used as mosquito control agent.
Inula racemose	Contain an active compound alantolactone which responsible to show larvicidal activity against Aedes albopictus and Asian tiger mosquito. [16]

Mode of Action of Phytochemicals in Insect Body

Secondary metabolites are the substances that extracted from plants which responsible for protecting them from herbivore. These metabolites are typically toxic, harmful to insects, and have an impact on target molecules such as proteins, bio-membranes, nucleic acids, and cellular components. As a result, the physiology of insects is disrupted, affecting nervous system functions like neurotransmitter synthesis, storage, release, and receptor activation. Theses phytochemicals act on the mosquito neurosystem by inhibiting cellular respiration and potassium –sodium exchange. A small number of phytochemicals produce a neural impulse that prevents insects and mosquitoes from transmitting nerve signals. [17]

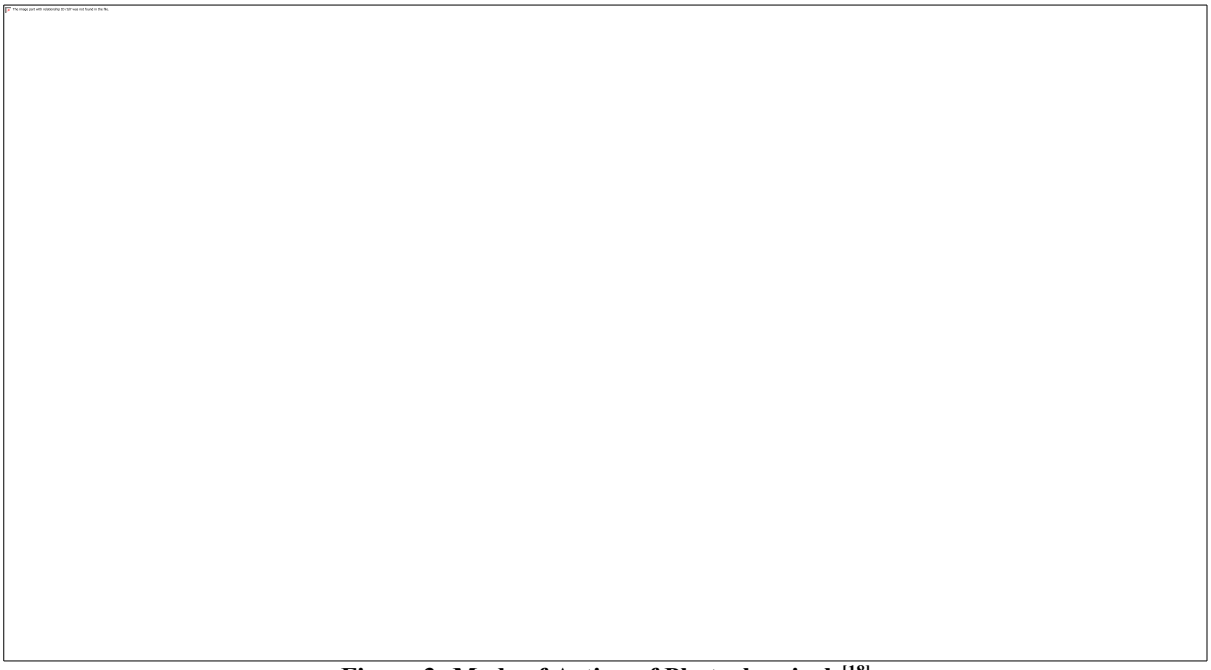

Figure 3: Mode of Action of Phytochemicals[18]

Synthetic Insect Repellents

Permethrin

Permethrin's method of action involves paralyzing the arthropod insect by inhibiting acetylcholinesterase and gamma-aminobutyric acid A receptors, which block sodium movement into neurons. It is a synthetic pyrethyroid with powerful insecticidal properties.

Allethrin

Common ingredient of vaporizer repellent is allethrin. Act by blocking sodium movement into neurons. It has been proven to be effective at repelling and killing mosquitos.

Malathion

It binds permanently to many sites on the cholinesterase enzyme where it releases peroxide. To the cholinesterase enzyme phosphoric ester group is attached strongly and deactivates it permanently. Due to this reaction quick spike of acetylcholine at the synapse, a junction between the nerve and muscle. After muscle response stimulation acetylcholine is breakdown by the cholinesterase enzyme and muscle stimulation is terminated. Excessive neural responses across synapses are triggered when the enzyme is disabled and leads to uncontrollable muscle movement and indicated paralysis and death. [19].

DEET ((N,N-diethyl-3-methylbenzamide)

Characterized as mosquito repellent from 60 years ago. They act by masking responses of olfactory receptor neurons (ORNs) to attractants. It shows its effects by activating specific odorant receptors (ORs) or specific ORNs.[20]

Table 2: Biological methods to control mosquitos

Entomopathogenic fungi	Entomopathogenic fungus play role in the management of infectious agents which cause malaria. Metarhizium, Culicinomyces, Entomophthora, Lagenidium and Caelomomuces these are the species utilised to control mosquito. Fungus act by targeting cuticles and the abdomen of mosquito larvae.
Planarians	The Planarians species Dugesia bengalensis Consume the mosquito larvae and eliminates the moqutio population
Control by beetles	Diptera, Odonata, Hemiptera and Coleoptera are the insects group which feed on mosquito larvae and reduce mosquitos in number.[21]
Bacterial Agents	On the basis of highly effective and non-toxicity Bacillus sphaericus and Bacillus thuringiensis is used to control malaria ventor. They both cause production of the endotoxin proteins that damage the stomach of larvae and its death occur.
Larvivorous Fish	Oldest method in which predatory fish Gambusia affinis and other species like family Cyprinodontidae is used to eat mosquito larvae.[22]

Other Methods

- **Mosquito net:** Sleeping under mosquito net provide better protection from mosquitos as compared to chemical methods because they may cause health hazards. Medicated mosquito net is also available and found to be a better option. Net is medicated with K-O (25% deltamethrin) tablets
- **Mosquito traps:** Mosquito attractants like human scent, body heat and exhaled carbon-di-oxide is used to capture female mosquito. By these attractants, insects approaches ad trapped in a device and then powered by electricity. It is a safe method.
- Electric mosquito zapper: Kills the mosquito by an electric charge. It work by using UV lights.
- **Mosquito Magnet**: It captures mosquito by giving off heat, moisture and Co2. It vacuums the insects into a net where they dehydrate and die.[23]

Conclusion

Lots of people are affected by mosquito-borne diseases and this results in an increase in mortality rates. For safety purposes, mosquito repellents are in demand, which discourage insects from landing on that surface. In today's world, human and environmental safety is of paramount importance. Only plant-based products are relatively safe, easy availability, cost-effective, and eco-friendly. Therefore, plant products are in high demand. There are several herbs available in different states of India which have potency to reduce mosquitoes in numbers and provide protection against mosquito-borne diseases. Thus, the present review provides information about plants that have potency to repel mosquitos and also about synthetic, biological methods and others.

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