

A Documentation of Traditional Methods of Mosquito Repellent Formulations Using Medicinal Plants in North-East India.

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ABSTRACT: Mosquitoes are a menace to humans. They not only buzz, bite and annoy us but are also vectors to many dreadful diseases like malaria, dengue, chikungunya, yellow fever etc. Many chemical formulations in the form of sprays, incenses, coils, lotions etc have been made over the years to repel or kill mosquitoes. However, many of these formulations are after all made from chemicals which can have a horde of side effects to humans as well as the environment. Therefore a search for some simple, effective and eco-friendly methods and formulations for mosquito repellency is the need of the hour.

India is a land of diverse ethnic cultures and each of them possess knowledge of a variety of home remedies and concoctions. Many of these remedies that use medicinal plants as ingredients are obscure and have yet to be known and researched. The region of North-East India is home to 145 tribal communities of the total 705 tribal communities in the country. All of these communities have their own home remedies and concoctions for many diseases, pest control, insect repellency and mosquito repellency.

In this context the present paper aims to review some traditional mosquito repellent plants and methods of mosquito repellency that people from North - Eastern states of India have been carrying out since ages ago and are still practicing today specifically in the rural regions. The paper also illustrates some bio-active components present in these plants that shows mosquito repellency.

I. INTRODUCTION

The North - Eastern region of India lies close to the tropics and the hence the climate here to a large extent resembles to that of a tropical one. Abundant rainfall, lush green forests and vegetations, numerous

hill streams combined with a hot and humid climate makes the region a choice habitat for menaces like mosquitoes. This in turn makes the region a hot bed for diseases like Malaria, Dengue and Chikungunya.

But how do mosquitoes find their human hosts? Mosquitoes locate their human hosts by combining chemosensory, visual, scent and thermal signals. The olfactory receptors present on the antennae, maxillary palps and proboscis of the mosquito sense the scent (sweat which is a mixture of chemicals like CO₂, lactic acid) coming off from the host. They also detect body heat and breath to find their blood hosts. Most mosquito repellents therefore work by masking the odour of the human host.

Many of the mosquito repellents available these days are chemical formulations. However they are not without side-effects, for example the case of DDT (sprayed as a mosquito repellent) which was used extensively few years back but was later found to have detrimental effect to not only humans but also to the environment (biomagnifications in birds) also in many cases the mosquitoes have already become resistant to these formulations. Therefore there is a need for effective eco-friendly natural formulations made from medicinal plants for repelling the menace of mosquitoes.

Many plant based formulations like Essential oils extracted from citronella, lantana, eucalyptus plants, Incense made from rosemary, lemongrass etc. are available and used today, many researches are still being conducted in search of a more efficient, effective and environment friendly natural mosquito repellents. The present review documents medicinal plants and the method of usage/administration for mosquito repellency that are used traditionally by the people of North-East India to tackle the problem of mosquitoes. People in this region use locally available materials (straw, husk, dung, twigs) and

medicinal plants to formulate ingenious mosquito repellents that are administered/ used in the form of smoke, fumes, plant juice, paste, cakes. Hence this review hopes to shed some more light on the traditional practices of mosquito repellency and medicinal plants, materials used by the people of the 8 states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura) that make up the North-East region of the country.

II. METHODS AND MATERIALS

We have searched literature on various medicinal plants that are known to have mosquito repellent properties in the NE region using the

keywords “medicinal plants”, “mosquito repellents”, “north-east India”. Additionally information was collected on various methods of traditional mosquito repellent formulations by locals from renowned newspapers, science magazines, books and case reports. Data was collected from databases like PubMed, Scopus, ScienceDirect, Google scholar, and several other journals. The studies chosen for inclusion in the review are based on methods of mosquito repellent formulations practiced by the people of NE India. Only published papers in English language and reports published in government website (nifr.org.in) were include in the review.

III. RESULT & DISCUSSION

Sl. No	Scientific Name	Common Name / Local Name	Family	Parts Used	Medicinal Uses	Method of Preparation	Mode of Administration	References
ARUNACHAL PRADESH								
1	*Canarium bengalense (Roxb.)	East Indian copal (Dhuna)	Burseraceae	Bark, Resin, Fruits	Bark used for Blood dysentery, Wound healing.	Resin from the bark is burned with coconut husk, ropes, twigs etc	Fumes from the burnt resin are fumigated throughout houses or buildings to repel mosquitoes .	Murtem et al., 2016
2	*Canarium resiniferum (Roxb.)	(Sanglam)	Burseraceae	Resin, Bark	Bark is powdered and applied on burns.	Resin from the bark is burned with coconut husk, ropes, twigs etc.	Fumes from the burnt resin are fumigated throughout houses or buildings to repel mosquitoes .	Gupta et al., 2005
3	Hedychium gracile (Roxb.)	(Bibu)	Zingiberaceae	Leaves , rhizome	Mosquito repellent , antifungal, used as	Oil is extracted .	Applied externally.	Perme et al., 2015

4	Litsea cubeba (Lour.)	(Santero)	Lauraceae	Leaves, Fruit	spices. Astringent, antiseptic, anti-inflammatory.	Extracted as essential oil.	Applied externally.	Boruah et al., 2019
5	Thelypteris dentata (Forssk.)	Downy maiden fern	Thelypteridaceae	Fronds	Swelling, blood vomiting, urinary disorders, insect repellent.	Leaves are dried.	Dried leaves are burnt and nearby areas are smoked to repel mosquitoes and insects.	Joshi et al., 2019
ASSAM								
6	Litsea salicifolia	(Dighloti)	Lauraceae	Leaves	Insect repellent, bark is used for asthma.	-	Used as incense.	Bhuyan & Chetia., 2018
7	*Azadirachta indica	Neem (Mahaneem)	Meliaceae	Leaves, bark	Insecticidal, parasitic infection, blood purification	Leaves are burnt. (used in Jag).	Smoke from burnt leaves repel mosquitoes.	Dua et al., 2009
8	*Adhatoda vasica	Malabar nut (Bahaktita)	Acanthaceae	Whole plant	Cure for bronchitis, tuberculosis, purify blood.	Planted in the vicinity of residential areas to repel mosquitoes.	Used in Jag	www.nif.org.in (herbal mosquito repellent plant)
9	Cuscuta reflexa (Roxb.)	Giant dodder (Akakhilota)	Convolvulaceae	Leaves, whole plant	Jaundice, wound healing	The plants and leaves are dried and mixed with cowdung, paddy straw &	Smoke from burning Jag are fumigated in and around houses or other buildings to repel	
10	Flemingia strobilifera (L.)	(Makhioti)	Fabaceae	Leaves, roots	To relieve pain, menstrual discomfort			

11	*Ocimum sanctum	Tulsi	Lamiaceae	Leaves	ort. Cough, fever, asthma, blood purifier.	husk. This is called Jag. Jag is burned for its smoke.	mosquitoes	
12	Polygonum glabrum (Willd.)	Dense flower knotweed (Bihlongoni)	Polygonaceae	Leaves	-			
13	*Homalomena aromatica (Roxb.)	(Gondhachana kochu)	Araceae	Dry rhizome	Joint pain, stomach pain, asthma, anti-inflammatory agent.	Essential oil is extracted and used to make incense	Burning incense.	Baruah., 2016
14	Eupatorium odoratum	(Kambilei)	Asteraceae	Leaves	Wound healing	Leaves crushed for juice.	Leaf juice is used for repelling mosquito.	Choudhury et al., 2011
15	Litsea glutinosa (Lour.)	(Baghnola)	Lauraceae	Bark	Bark is used to relieve pain.	Paste used to form incense/cakes along with leaves of H. aromatic, O. basilicum.	Incense/cakes for burning	Baruah., 2016
16	Triumfetta rhomboidei	(Bon Agora)	Malvaceae	Aerial parts	Insect repellent	-	Incense.	Bhuyan & Chetia., 2018
17	*Cymbopogon nardus	Citronella	Poaceae	Leaves	Cure for colic and stomach problem.	Essential oil extracted from leaves/	Oil & juice applied externally.	Kalita et al., 2012

						leaves are crushed for juice		
MANIPUR								
18	Arundo donax (L.)	(Giant weed)	Poaceae	Leaves	Mosquito repellent	Dried leaves are burnt.	Smoke from burning of the dried leaves is used as mosquito repellent.	Kantheti et al., 2017
19	*Citrus grandis	Pomelo (Nobab)	Rutaceae	Fruit peel	Dyspepsia	Dried peel is used to repel mosquitoes.	Dried peel is burnt and smoked to repel mosquitoes.	Debet al., 2016
20	Citrus reticulata (Blanco.)	(Komla)	Rutaceae	Dried peel	Fever, edema, asthma.	Dried peel is used to repel mosquito.	Dried orange peels burnt to repel mosquitoes.	Badawy et al., 2017
21	*Eucalyptus citriodora (Hook.)	(Nasik)	Myrtaceae	Leaves	-	Essential oil is extracted from leaves.	eucalyptus oil shows mosquito repellence	Singh et al., 2007
22	Leucas aspera	(Mayang-lembung)	Lamiaceae	Leaves	Scabies, larvicidal activity	Leaves are dried for burning.	Used as mosquito repellent in rural areas by burning dry leaves.	Devi et al., 2012
23	Nicotiana tabacum (L.)	Tobacco	Solanaceae	Leaves	Insect repellent	Juice is extracted	Extract is applied on the skin	Kantheti & Alapati., 2017
24	Vitex trifolia (L.)	(Urik-shibi)	Lamiaceae	Leaves	Treating pediculosis, lice infection, uterine inflammations.	-	Oil extract used as repellent.	Devi et al., 2015
MEGHALAYA								
25	Litsea citrate	May chang	Lauraceae	Fruit	Insect repellent	-	-	Kantheti &

26	Randia longiflora	Indigo berry	Rubiaceae	Fruit	Insect repellent, insecticidal.	-	-	Alapati 2017
27	*Zanthoxylum acanthopodium	Lemon pepper	Rutaceae	Fruit	Mosquito repellent	Oil extracted from fruit	Externally applied	Sharma, (2018)
MIZORAM								
28	Adhatoda zeylanica	Malabar nut (Kawldai)	Acanthaceae	Leaves	Loosen chest congestion, open bronchi, treat spasms.	Leaves are dried and burned	Fumes of dried leaves are used to repel mosquitoes	Kantheti & Alapati, 2017, Prabhat et al., 2010
29	Callitris glauca	Cypress pine	Pinaceae	Branch, cone	Cough and cold bronchitis	Oil is extracted from the wood.	Oil applied externally on body parts as mosquito repellent	
30	Clousena anisata	Horse wood	Rutaceae	Bark, fruit, leaves	Control inflammation, reduce accumulation of fluid.	Leaves dried and burnt	Fumes of dried leaves are used to repel mosquitoes	
31	*Ocimum tenuiflorum (L.)	Holy basil (Runhmuidum)	Lamiaceae	Leaves	Antioxidant, ease inflammation, adaptogen	Juice extracted from leaves.	Leaf juice applied externally	Rai & Lalramghinglova., 2010
NAGALAND								
32	Ageratum conyzoides (L.)	Billy Goat weed (Houhung)	Asteraceae	Whole plant		Leaves are dried and burnt.	Fumes of dried leaves used as mosquito repellent	Kantheti & Alapati., 2017
33	Arisaema concinnum	Chinese cobra lily (Hoyanghek)	Araceae	Leaves, tubers	Anticoagulant, anti-inflammatory	Tubers are dried for burning.	Fumes of dried tubers are used as mosquito repellent	

34	Artemisia nilagirica (Clarke)	(Penianiap fii)	Asteraceae	Leaves	Insect repellent, Piles cure	Leaves are pounded for juice.	Decoction of leaf applied topically	Chase et al., 2013
35	Cucumis sativus (L.)	(Zungi)	Cucurbitaceae	Leaves	Stomach discomfort, flatulence, hyperacidity	Leaves are crushed to extract juice.	Leaf juice applied externally on the exposed area to repel mosquito.	Jamir et al., 1999, Kantheti & Alapati., 2017
36	*Cymbopogon citratus (Stapf.)	Lemon grass	Poaceae	Leaves, stem	Relaxing anxiety, relieving bloating.	Oil extraction	Leaf extract applied externally	
37	*Lantana camara	Wild sage	Verbenaceae	Leaves, roots, flowers	Chicken pox, relief from headache, flu.	Oil extracted from leaves	Oil applied externally on skin	
38	Elsholtzia blanda (Benth.)	Pleasant himalayan mint (Ninghui)	Lamiaceae	Leaves	Anti-bacterial, anti-pyretic, anti-viral treatment of fever, cold.	Leaf extracted. Dried leaves are burnt.	Leaf extract applied externally on skin. Fumigation of dried plant is used as repellent.	Shankar et al 2016; Singh et al., 2015
39	Melissa officinalis	Lemon balm (Nonem)	Lamiaceae	Whole plant	Mosquito repellent, deworming.	Leaves are used for extraction of juice or oil.	Essential oil used as mosquito repellent	Thurso et al., 2017
40	Nicotiana Plumbaginifolia (Viv.)	Sada	Solanaceae	-	Insect repellent	-	Leaf paste applied topically	Chase et al., 2013
41	*Ocimum gratissimum (L.)	Ram tulsi	Lamiaceae	Leaves	Antioxidant, adaptogen, gonorrhoea,	Plant juice is extracted	Applied externally on skin	Jamir et al., 2016

					paralysis			
SIKKIM								
42	Acorus calamus	Sweet cane (Bhojo)	Acoraceae	Root, rhizome.	Fever, cough, pharyngitis, bronchitis, sore throat	Dried root or rhizome is burned along with dung	Fumes from the burning of dried root and dung/charcoal act as repellent	Kantheti & Alapati, 2017
43	Anacardium occidentale	Cashew	Anacardiaceae	Fruit rind	-	Rind of the fruit is burnt	Fume is spread in and around the house to repel mosquitoes	
44	*Artemisia vulgaris (L.)	(Titeypathi)	Asteraceae	Whole plant	Gout, rheumatism, ulcer	Leaves are dried to burn with Dhoop.	Dried leaves are mixed with dhoop to repel mosquitoes	Palit & Banerjee, 2016; Bam et al., 2015
45	Backhousia myrtifolia	Cinnamon	Myrtaceae	Leaves	Dyspepsia treatment	Leaves are crushed to extract juice	Leaf juice rubbed externally.	Kantheti & Alapati, 2017
46	*Curcuma longa	Turmeric (Haldi)	Zingiberaceae	Rhizome, leaves	Throat pain, wound healing	Rhizome is made into a paste	Paste of the rhizome is applied externally.	
47	Hyptis suaveolens (L.)	Pig nut	Lamiaceae	Leaves, roots, seeds.	Antifungal, oxidative stress treatment	Leaves are pounded and juice is extracted	Leaves extract applied externally.	
48	Dysphania ambrosioides	Mexican tea	Amaranthaceae	Leaves, seed	Antihelmintic, influenza, pneumonia	Oil extract	Oil extract acts as mosquito repellent.	Stappen et al., 2018

					monia			
49	<i>Juniperus communis</i> (L.)	Dhupi	Cupressaceae	Needles, fruits, leaves	Stimulant, diuretic properties	Needles are burnt as incense	Incense	
50	<i>Zanthoxylum armatum</i>	Indian prickly ash (Bokaytimbur)	Rutaceae	Twigs, fruits, seeds, leaves	Toothache relief, antiseptic, disinfectant	Essential oil extracted from fruits, seeds, leaves.	Oil applied externally or in incense burners.	Singh & Singh., 2011 & Bam et al., 2015
TRIPURA								
51	* <i>Cocos nucifera</i> (L.)	Coconut (Narikwra)	Arecaceae	Fruits, leaves and stem	Oil is good for hair, good cholesterol.	The husk is burnt along with resin from <i>Canarium</i> sp. Tree (dhuna)	The smoke from the dhuna helps in repelling mosquitoes.	Sharma et al., 2013
52	<i>Kaempferia rotunda</i> (L.)	Indian crocus (Bhojoraphul)	Zingiberaceae	Flower, rhizome	Skin infection, jaundice	Flower and rhizome are used to make incense	Burning incense sticks.	Kantheti & Alapati., 2017
53	<i>Kalanchoe pinnata</i> (Pers.)	Miracle leaf (Khurajot)	Crassulaceae	Leaves	Jaundice, dysentery, diarrhoea, skin infection	Leaf juice extracted	Extract is applied on the exposed parts.	Das et al., 2012

Table 1: Medicinal plants used as mosquito repellents in North East India.

Searching through various research papers, journals, books and websites we have found 53 species of plants belonging to 27 families that are used in NE India (Table 1). Out of the 27 families studied, Lamiaceae (8), Rutaceae (5), Lauraceae (4), Asteraceae (4), Poaceae (3), Zingiberaceae (3) are predominant in terms of number of species used in mosquito repellency. 17 species of plants namely

Canarium bengalense, *Canarium resiniferum*, *Azadirachta indica*, *Ocimum sanctum*, *Cymbopogon nardus*, *Citrus grandis*, *Ocimum tenuiflorum*, *Cymbopogon citratus*, *Ocimum gratissimum*, *Artemisia vulgaris*, *Curcuma longa*, *Cocos nucifera*, *Adhatoda vasica*, *Zanthoxylum acanthopodium*, *Eucalyptus citriodora*, *Homalomena aromatica*, *Lantana camara* are commonly used in different parts

of NE and have been reported by more than one author. The plant species used in traditional methods of mosquito repellency are commonly found in the vicinity or are collected from the nearby forests and hills. Excluding the 17 species of plants commonly used in more than one of the states, 7 species of mosquito repelling plants are reported from Assam, 7 from Nagaland, 7 from Sikkim, 5 from Manipur, Arunachal Pradesh reports 3 species of plants while 3, 2 and 2 species of plants were reported from Mizoram, Tripura and Meghalaya respectively.

The people of North East have been utilizing these plants in their own traditional formulations or methods to repel mosquitoes. In most formulations, leaves of the plants are used followed by stem, bark, resins, rhizomes, seeds, fruits, whole plant and cones. Leaves are crushed to extract juice, pounded into paste, pressed to extract essential oils or dried to burn for smoke. Stems are also crushed for juice, made into incense or dried for burning. Bark, cones and rhizomes are pounded into paste or dried. Resins are burnt with other materials and plants (such as coconut husk, twigs), seeds and fruits are crushed to extract juices, oils or made into a paste. The rind of the fruits and seeds are dried and burnt for smoke.

In Arunachal Pradesh, mostly leaves of the plants are used, either for their juices or essential oils and are applied externally on exposed part of the skin. Apart from leaves, resin from *Canarium bengalense*, *Canarium resiniferum* are dried and made into fine powder that is sprinkled over burning coal, coconut husk or dried twigs (called Dhuna). Dense fumes coming out of the Dhuna are fumigated in and around houses, shops or buildings to repel mosquitoes. Dhuna is practiced as a religious rite as well as a mosquito repellent in the states of Assam and Tripura. In Assam, people use Dhuna, as well as a traditional method known as Jag. To make the age old traditional Jag, leaves of *Cuscuta reflexa* (Akakhilota), *Polygonum glabrum* (Bihlongoni), *Ocimum sanctum* (Tulsi), *Flemingia strobilifera* (Makhloti), *Litsea salicifolia* (Dighloti), *Azadirachta indica* (Neem) are dried and mixed with paddy husk/coconut husk, straw/ cow dung and then burnt. The fumes coming out from the mixture is used as mosquito repellent. A project under the “National children science congress 2001” titled “Study on the use of medicinal plants, as mosquito repellent in Assamese society with special reference to Jag” was undertaken by Leena Talukdar and Shushanta Mahanta of Morigaon district, Assam. The project found the plants used in Jag to be useful in repelling

mosquitoes out of which *Flemingia strobilifera* (Makhloti) was found to have repelled 90% mosquitoes. They had formulated an herbal formulation using dried powdered leaves of the plants along with the Dhuna resin to burn; fumes arising from the Jag were then used to repel mosquitoes. The project was awarded an appreciation award at the 3rd National Grassroots Innovation award, 2005. The whole description of the project can be found in the website of National Innovation Foundation – India (www.nif.org.in). Apart from the Jag, leaves of plants like neem, *Eupatorium odoratum*, *Cymbopogon nardus*, are crushed and their juice applied on body parts as a repellent.

In Manipur leaves of *Leucas aspera*, *Vitex trifolia*, *Arundo donax* are dried and burned to repel mosquitoes where as fruit rind of *Citrus reticulata*, *Citrus grandis* are also dried to burn. Essential oil extracted from leaves of *Eucalyptus citriodora* are applied externally as a repellent. Baruah., 2016 formulated an herbal mosquito repellent cake using dried powder of leaf and bark of *Homalomena aromatica*, *Ocimum basilicum*, *Ageratum conyzoides*, *Litsea glutinosa*. The prepared cakes showed significant mosquito repellency.

Not many studies are reported from Meghalaya, Mizoram and Tripura and hence there is a dearth of reported data. Majorly essential oils and juice extracted from leaves, fruits, seeds of *Homalomena aromatica*, *Litsea citrate*, *Randia longiflora*, *Zanthoxylum acanthopodium*, *Adhatoda zeylanica*, *Callitris glauca*, *Clousena anisata*, *Ocimum tenuiflorum* are applied externally on skin or the leaves are dried and burned for their smoke to repel mosquitoes as reported by Lalramnghinglova., 2016; Kantheti & Alapati., 2017; Rai & Lalramnghinglova., 2010. In Nagaland, most of the reported plants are used for their leaves & tubers which are either dried for burning or crushed for juice to be applied externally. Extracted essential oils are also used in incense burners or applied on the skin as reported by Jamir et al., 1999; Chase et al., 2013; Singh et al., 2015; Shankar et al., 2016; Kantheti & Alapati., 2017; Thurso et al., 2017. In Sikkim, like the other NE states leaves of plants are used most followed by rhizomes. Leaves of plants like *Artemisia vulgaris* are dried and burned along with Dhoop to repel mosquitoes, Palit & Banerjee., 2016; Bam et al., 2015. Leaves of other plants like that of *Hyptis suaveolens*, *Backhousia myrtifolia* are crushed and their juice applied externally, Kantheti & Alapati., 2017. Rhizomes of *Acorus calamus*, *Curcuma longa*

are either dried for burning or pounded into paste to apply externally, Kantheti & Alapati., 2017. Essential oils of *Zanthoxylum armatum*, *Juniperus communis*, *Dysphania ambrosioides* were found to have mosquito repellent property by Singh & Singh., 2011; Stappen et al., 2018.

IV. CONCLUSION

This paper aims to review traditional methods of mosquito repellency using medicinal plants in the NE states of India, a region that is yet to be explored and researched. Much of the traditional knowledge about medicines and medicinal plants in the region exists in memories and practices but do not have any written records. Traditional practices might seem ritualistic but often possess deep scientific values which need to be studied as well as researched upon. This paper is to provide a brief document about the potential plants that can be studied in depth for formulation of effective and safe mosquito repellents.

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