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Insecticidal properties of different plants of north-east India against *Aedes aegypti* and *Culex quinquefasciatus*: A review

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Abstract
North-East India is considered as one of 34 biodiversity hotspots across the world. The rich floral diversity of this region is less highlighted for its insecticidal property. Being a major vector of different dreadful diseases, mosquito gain more importance in now-a-days. Such mosquito population are trying to control using chemical agents but botanicals are considered as safe and effective alternative to chemical insecticide in recent times. In this context, North-East India hold a specific position due to its high floral diversity. Therefore, our investigation has targeted to record the study which tested mosquitocidal properties of plant essential oils against two important vector mosquito species *viz*. *Aedes aegypti* and *Culex quinquefasciatus* in this particular area. The present review reported that 52 and 54 plant essential oils from different plant parts have tested against *Aedes aegypti* and *Culex quinquefasciatus*. Majority of these essential oils were obtained from leaves part of the Rutaceae family.

Keywords: *Aedes aegypti*, botanicals, *Culex quinquefasciatus*, Mosquitocides, North-East India

Introduction
North-East India includes eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim with a total area of 2,62,180 km^2. This region covers about 8% area of India having population of approximately 40 million. This region holds a unique position in world map due to its biodiversity. It is considered as one of 34 biodiversity hotspots across the world. The topographical condition, climatic variation, soil properties and geographical position add extra advantage to this place for holding maximum bio resources including both flora and fauna. The NE India is in peculiar position from the point of plant diversity as it has numerous species of medicinal plants, timber plants along with other species with insecticidal properties. With advancement of time, the diverse natural resources of NE India have faced great threats of extinction due to over exploitation and indiscriminate use of forest for fuel, timber, medicine along with the natural calamities.

A good number of floras from NE India has been studied for their medicinal value but yet a few only targeted to evaluate for their insecticidal properties. Among such, research related to mosquitocidal properties of plant species from this region is very limiting. Owing to the fact that usage of synthetic chemicals for the control of vector mosquito populations creates severe effect on the environment as well as non-target organisms, recent research has tried to incorporate bio pesticide in such programs. Biopesticides are advantageous as mosquitocide for their low pollution affect, low toxicity, biodegradability, low cost, easy to use etc. [1-4]. In this context importance of plant products like essential oil, extracts from different parts, their constituent compounds gain more importance. With rich source of biodiversity, NE India possesses a good scope of such research to develop effective mosquitocides.

Mosquitoes are medically important species and are considered as major public heath pests as they can transmit more dreadful diseases to human and other warm-blooded vertebrates than other groups of arthopods. WHO has declared the mosquito “public enemy number one” as they are responsible for the transmission of various dreadful diseases through blood sucking [5].

Aedes aegypti and *Culex quinquefasciatus* are such mosquito species under Culicidae family which transmits different diseases like chikungunya, dengue, zika, filariasis, Japanese encephalitis etc. Such diseases directly and indirectly cause morbidity, mortality and economic burden to humankind. Every year about 700 million persons get affected by diseases transmitted by mosquitoes. More people died every year from mosquito borne disease than from any other single cause diseases [6].

Aedes aegypti is a common mosquito species of tropical and sub-tropical countries having distinct white bands in their legs and abdomen. It has its highest current distribution in urban areas worldwide and bears more medical importance for its vectorial capacity. It harbors lots of virus species associated with various dreadful diseases like dengue, zika etc. The insect's diurnal haematophagic activity, the synanthropic behavior and anthropophilic habits associated with the physical complexity of urban centers have hampered its combat [7].

Each year dengue virus infection records more than 100 million of classic cases and more than 500 thousand cases of dengue hemorrhagic fever worldwide [8]. In 2012 dengue was considered the most important mosquito-borne viral disease in the world being epidemic in over 100 countries of the tropical and subtropical regions. In recent years, *Aedes aegypti* is also reported as the vector of chikungunya virus which affected the southwest Indian Ocean islands in 2005, spread out to India, and resulted in an ongoing outbreak that has involved >1.5 million patients [9].

Again, *Culex quinquefasciatus*, an important vector of filariasis is a predominant house-resting mosquito in many tropical countries. Lymphatic filariasis is one of the fastest insects spreading disease of man in the tropics caused by *Wuchereria bancrofti.* It almost affects 120 million people worldwide, and 44 million people have common chronic manifestation [10]. According to WHO, about 90 million people worldwide are infected with *W. bancrofti*, the lymphatic dwelling parasite, and ten times more people are at the risk of being infected [11]. In India alone, 25 million people harbour microfilaria (mf) and 19 million people suffer from filarial disease manifestations [12, 13].

Thus, in is very urge to control vector mosquito population to control different mosquito transmitted diseases. Lots of control measures were taken worldwide to prevent the spreading of such mosquito-borne diseases but most of them are failed due to resistance development against them by the target insect populations [14]. In this context botanicals gain more importance in recent times as safe and effective mosquitocide. Plants possess a rich pool of biologically active chemicals which can be successfully implanted in mosquito control program [15, 16]. As a great reservoir of natural resources, NE India bears more scope in this field of insecticide development. Therefore, this article was aimed to review such research in NE India against two important vector mosquito- *Aedes aegypti* and *Culex quinquefasciatus*.

Botanicals as mosquitocide

Plant derived products are simply termed as botanicals including plant extracts, secondary metabolites, phytochemicals and their mixtures etc. Such botanicals have a long history of usage in the field of medicine development and insect population control management. As early as there was a report regarding the usage of *Dalmatian pyrethrum* flowers (contain 1.5% pyrethrin) against numerous pests like cockroaches, mosquitoes, bugs etc. [1].

A large number of plant species mainly the aromatic ones are known to have essential oil in their body parts which are mainly odorous, volatile and provide defense against pest and herbivory animals. Such essential oils from different family of plants were tested against different insects including mosquitoes for controlling their population and the research continues till now. Till date, more than 2000 plant species have been known to produce secondary metabolites of value in biological pest control programs and among these, products of some 344 species have been reported with significant activity against mosquitoes. The plants of Solanaceae, Asteraceae, Cladophoraceae, Labiatae, Miliaceae, Oocystaceae and Rutaceae families were extensively studied against various development stages of mosquito [18].

Chemically essential oils are a blend of terpenes, terpene derivatives, terpenoids etc. Looking back to the previous literature, it was noticed that essential oils were widely tested for their mosquitocidal properties. *Aedes aegypti*, *Culex quinquefasciatus* and *Anopheles stephensi* were targeted by maximum number of such studies [19-33]. For the enhancement of efficacy of essential oils as mosquitocide, some studies also prepared and tested different mixtures of essential oils [34].

As an important component of crude essential oil, their constituent compounds were also tested individually in numerous investigations [35-42] or in combinations with others [35, 43-48]. Simultaneously a large number of plant extracts were also well targeted by the researcher to evaluate their toxicity against mosquitoes [49-53].

Mode of action of botanicals

Botanicals are generally slow in action in comparison to chemical insecticides but they are highly effective and less prone to resistant development. Although detailed investigation has not been performed regarding the mode of action of the botanicals on the physiology of different insect species but some of the previous studies attempted to study their effect on the detoxification mechanism [54], ion channels as well as vital physiological process [55, 56]. The plant secondary metabolites are full of numerous compounds each of which possesses unique or joint target pathway. Such target components include nervous system, cell surface receptor or other metabolic pathways [57]. A good number of previous studies have reported that secondary metabolite may affect glucose receptor of insect mouthparts [58], endocrine balance [56], different growth regulators [59, 60], ion channels [61, 62] etc. Botanicals like nicotine (derived from tobacco plants) has a good record of usage as insecticide which mainly target neurotransmitter [63]. Others like essential oils from Neem, Mentha etc. have reports to target on acetylcholinesterase enzyme activity [64-67]. The effects of thymol and other plant-based compounds on voltage gated channel and ion channel of the insect body was also discussed throughout the study of Ratra and Casida (2001), Priestley *et al.*, (2003) and Bloom Quist *et al.*, (2008) [68-70]. Casida (1973) also mentioned mitochondrial system disruption as one of the important mechanisms of Pyrethrin [71].

Factors affecting use of botanical insecticides

Botanical insecticides possess a broad array of future prospective for the control of different insect population but due to some limitations it does not replace chemical

insecticides till now. Restriction on the collection and availability of different raw plant materials is one of the major drawbacks in the field of botanical insecticide development. Along with that there is a little bit complexity in the standardization of botanicals as its constituents have broader range of volatility and solubility. Type of solvents, plant species, collection weather as well as used plant parts and extraction process also might affect the activities of plant-based insecticides. Presence of such drawbacks botanicals has low value in marketing as compared to chemical insecticides. The pesticide activity of botanicals might also be influenced by other factors *viz*. the amount and types of active ingredients, the exposure time, the applied concentration and quantity, applied season and climate etc. [72, 73]. Additionally regulatory scheme is an important barrier in the commercialization of new botanical insecticide. Risk assessment of such products on human and environment is also a long process which put a limitation on fruitful application of botanicals. Till now essential oils were frequently used in food flavoring industry and such usage have not impact on plant population biomass but extensive usage of such botanicals in case of insecticide development to fulfil the growing demand for its safety purpose may bring a remarkable effect on plant biomass. For mitigating this demand, recent studies have introduced synthetic way to natural products and tried to develop mixture of multiple botanicals as a solution of plant diversity destruction.

Research in NE India

In search of for alternating insecticides to be used in vector control programme botanicals gain more importance in recent times. In this context NE India holds a unique position for its rich biodiversity. But in comparison to others parts of the world, little attention has paid in NE region regarding the study of insecticidal properties of plant materials as mosquitocide. Slow rate of development, proper validation of traditional knowledge as well as lower interest towards research work might be the factors behind such scenario. The present literature review reported that 52 and 54 plant essential oils from different plant parts have tested against *Aedes aegypti* and *Culex quinquefasciatus*. Majority of these essential oils were obtained from leaves part of the Rutaceae family. Our investigation has targeted to record the study which tested mosquitocidal properties of plant essential oils against two important vector mosquito species *viz*. *Aedes aegypti* and *Culex quinquefasciatus*. With increasing number of dengue cases worldwide in severe form it is urge to develop mosquitocide against *Aedes aegypti*. Failure of vaccine development against different serotyoes of DEN virus again has boosted such study. Additionally control of *Culex quinquefasciatus* has gain importance now-a-days for its ever-increasing rate of population in new areas. The studies of essential oils as insecticide against *Aedes aegypti* in NE India include 27 families including 52 species (Table-1) and 21 families where 54 species (Table-2) were included in case of *Culex quinquefasciatus*. Most of them are native to Assam and majority of such works were performed in this region in comparison to other states of NE India. The leaves of the selected plants were mostly used in the earlier studies along with the seeds, barks majority of which targeted the larval stage of the two vector mosquito species.

Table 1: Different plant species studied for their mosquitocidal properties against *Aedes aegypti* in North-East India

SL No	Plant species	Vernacular name	Family	Part used	Plant origin	Reference
1	*Aegle marmelos*	Bael	Rutaceae	Leaves	Different villages of Northeast India	[74]
2	*Ipomea cornea*	Morning glories	Convolvulaceae	Leaves	Different villages of Northeast India	[75]
3	*Splianthusacmela*	Daisy	Asterceae	Whole plant	Different villages of Northeast India	[75]
4	*Litsea salicifolia*	Dighloti	Lauraceae	Leaves	Different villages of Northeast India	[75]
5	*Houttuynia cordata*	Lizard tails	Sauraceae	Leaves	Different villages of Northeast India	[75]
6	*Camellia sinesis*	Tea shrub	Theaceae	Leaves	Different villages of North East India	[75]
7	*Shorearobusta*	Shala tree	Dipterocarpeaceae	Latex	Different villages of Northeast India	[75]
8	*Pongamiun pinnata*	Karenji	Fabaceae	Seeds	Outskirts of Guwahati, Assam	[76]
9	*Croton tiglium*	Konibih	Euphorbiaceae	Seeds	Outskirts of Guwahati, Assam	[76]
10	*Cascabelathevetia*	Karabi	Apoceneceae	Seeds	Outskirts of Guwahati, Assam	[76]
11	*Datura stramonium*	Dhutura	Solanaceae	Seeds	Outskirts of Guwahati, Assam	[76]
12	*Ricinus communis*	Era	Euphorbiaceae	Seeds	Outskirts of Guwahati, Assam	[76]
13	*Azadirachta indica*	Neem, mohaneem	Meliaceae	Seeds	Outskirts of Guwahati, Assam	[76]
14	*Litsea salicifolia*	Dighloti	Lauraceae	Leaves	Foothills of Guwahati City, Assam	[77]
15	*Piper negrum*	Black pepper	Piperaceae	Stem	Foothills of Sonitpur District, Assam	[78]
16	*Murrayakoenigii*	Curry leaf	Rutaceae	Leaves	Kamrup District, Assam	[33]
17	*Ficus benghalensis*	Banyan fig	Moraceae	Leaves	Kamrup District, Assam	[33]
18	*Houttuynia cordata*	Lizard tails	Souruaceae	Leaves	Kamrup District, Assam	[33]
19	*Callistemon linearis*	Bottle brush	Myrtaceae	Leaves	Kamrup District, Assam	[33]
20	*Psidium guajava*	Common guava	Myrtaceae	Leaves	Kamrup District, Assam	[33]
21	*Eupatorium odoratum*	Siam weed	Asterceae	Leaves	Kamrup District, Assam	[33]
22	*Ageratum conyzoids*	Chickweed	Asterceae	Leaves	Kamrup District, Assam	[33]
23	*Zingeber officinale*	Ginger	Zingiberaceae	Leaves	Kamrup District, Assam	[33]
24	*Polyalthia longifolia*	Ashoka	Pinaceae	Leaves	Kamrup District, Assam	[33]
25	*Spondias pinata*	Amra	Anacardiaceae	Leaves	Kamrup District, Assam	[33]
26	*Lantana camara*	Lantana	Verbenaceae	Leaves	Kamrup District, Assam	[33]
27	*Homalomenaaomatica*	Sugandhmantri	Araceae	Leaves	Kamrup District, Assam	[33]
28	*Ocimum sanctum*	Tulsi	Lamiaceae	Leaves	Kamrup District, Assam	[33]
29	*Eucalyptus maculata*	Spotted gum	Myrtaceae	Leaves	Kamrup District, Assam	[33]
30	*Mentha piperita*	Peppermint	Lamiaceae	Bark	Kamrup District, Assam	[33]

31	*Allium sativum*	Garlic	Amaryllidaceae	Bulbs	Kamrup District, Assam	[33]
32	*Plumeria rubra*	Red jasmine	Magnoliaceae	Flower	Kamrup District, Assam	[33]
33	*Cassia fistula*	Cassia	Fabaceae	Seed	Kamrup District, Assam	[33]
34	*Vitem negundo*	Posatia	Lamiaceae	Leaf	Namsai District, Arunachal Pradesh	[79]
35	*Ocimum sanctum*	Tulsi	Lamiaceae	Leaf	Namsai District, Arunachal Pradesh	[79]
36	*Christella parasitica*	Bhilangoni	Thelypteridaceae	Leaf	Namsai District, Arunachal Pradesh	[79]
37	*Citrus grandis*	Robab tenga	Rutaceae	Leaves and peel	Nalbari District, Assam	[74]
38	*Piper longum*	Pipoli	Piperaceae	Leaf	Sonitpur District, Assam	[80]
39	*Ocimum sanctum*	Tulsi	Lamiaceae	Leaf	Sonitpur District, Assam	[80]
40	*Splianthusacmela*	Daisy	Asterceae	Leaf	Sonitpur District, Assam	[80]
41	*Piper negrum*	Jaluk	Piperaceae	Seed	Sonitpur District, Assam	[80]
42	*Toddalia asiatica*	Jaluk bon	Rutaceae	Fruits and leaves	Sibsagar District, Assam	[81]
43	*Cymbopogon nardus*	Citronella	Poaceae	Leaves	Sibsagar District, Assam	[81]
44	*Eucalyptus globulus*	Eucalyptus	Myrtaceae	Leaves	Sibsagar District, Assam	[81]
45	*Pogostemoncablin*	Patachauli	Lamiaceae	Leaves	Sibsagar District, Assam	[81]
46	*Aristolochiasaccata*	Pouch birthworth	Aristolochiaceae	Root	Foothills of Sonitpur District, Assam	[78]
47	*Annona squamosa*	Custard apple	Magnoliaceae	Root	Foothills of Sonitpur District, Assam	[78]
48	*Gymnopetelumcochinchenesis*	Batijhinga	Cucurbitaceae	Fruit, pericarp	Foothills of Sonitpur District, Assam	[78]
49	*Caesalpinea species*	Peacock flower	Fabaceae	Bark	Foothills of Sonitpur District, Assam	[78]
50	*Piper*	Pepper	Piperaceae	Stem	Foothills of Sonitpur District, Assam	[78]
51	*Lippia alba mill*	Pikachi bon	Verbenaceae	Leaves	Jalukbari, Guwahati, Assam	[82]
52	*Citrus aurantifolia*	Key lime	Rutaceae	Leaves and peel	Kamrup District, Assam	[32]

Table 2: Different plant species studied for their mosquitocidal properties against *Culex quinquefasciatus* in North-East India

SL No	Plant Species	Vernacular Name	Family	Part Used	Plant origin	Reference
1	*Pongamia pinnata*	Ksrenji, Korash	Fabaceae	Seeds	Outskirts of Guwahati, Assam	[76]
2	*Croton tiglium*	KoniBih, BihGuti	Euphorbiaceae	Seeds	Outskirts of Guwahati, Assam	[76]
3	*Cascabelathevetia*	Karabi	Apocynaceae	Seeds	Outskirts of Guwahati, Assam	[76]
4	*Datura stramonium*	Dhutura, Dhatura	Solanaceae	Seeds	Outskirts of Guwahati, Assam	[76]
5	*Ricinus communis*	Eragoach, Era, Irritong	Euphorbiaceae	Seeds	Outskirts of Guwahati, Assam	[76]
6	*Azadirachta indica*	Neem, Nim, MohaNeem	Meliaceae	Seeds	Outskirts of Guwahati, Assam	[76]
7	Toddalia asiatica	JalukBon, Tezmui	Rutaceae	Fruits, Leaves	Sibsagar, Assam	[83]
8	*Litsea salicifolia*	Dighloti	Lauraceae	Leaves	Guwahati, Assam	[77]
9	*Aegle marmelos*	Beal	Rutaceae	Leaves	Nalbari, Assam	[74]
10	*Derris elliptica*		Fabaceae	Root, Shoot	Nambor Forest (Golaghat, Assam)	[16]
11	*Linostomadecandrum*	Bakalbih, Ruteng	Thymeleaceae	Root, Shoot	Nambor Forest (Golaghat, Assam)	[16]
12	*Croton tiglium*	Konibih	Euphorbiaceae	Seeds	Hozai (Nagaon, Assam)	[16]
13	*Litsea salicifolia*	Dighloti	Lauraceae	Arial parts	Titabor (Jorhat, Assam)	[16]
14	*Croton caudatus*	Lata-mahudi	Euphorbiaceae	Root	Mariani (Jorhat, Assam)	[16]
15	*Zanthoxylum limonella*	Bezarmoni	Rutaceae	Pericarp	Sonitpur, Assam	[80]
16	*Piper nigrum*	Jaluk	Piperaceae	Seed	Sonitpur, Assam	[80]
17	*Spilanthesacmella*	Pirazha	Asteraceae	Leaf	Sonitpur, Assam	[80]
18	*Piper longum*	Pipoli	Piperaceae	Seed	Sonitpur, Assam	[80]
19	*Citrus aurantifolia*	Saklatenga	Rustaceae	Peel	Sonitpur, Assam	[80]
20	*Mentha arvensis*	Pudina	Lamiaceae	Leaf	Sonitpur, Assam	[80]
21	*Tagetespatula*	Nargee	Asteraceae	Flower	Sonitpur, Assam	[80]
22	*Lippianodiflora*	Nemusak	Verbenaceae	Leaf	Sonitpur, Assam	[80]
23	*Chrysanthemun cinerariifolium*	Indramalati	Asteraceae	Leaf	Sonitpur, Assam	[80]
24	*Capsicum annuum*	Jalakia	Solanaceae	Fruit	Sonitpur, Assam	[80]
25	*Leucas linifolia*	Doron bon	Lamiaceae	Leaf	Sonitpur, Assam	[80]
26	*Lantana camara*	Guti phul	Verbenaceae	Leaf	Sonitpur, Assam	[80]
27	*Ocimum sanctum*	Kola Tulshi	Lamiaceae	Leaf	Sonitpur, Assam	[80]
28	*Moringa oleifera*	Sajina	Moringaceae	Root	Sonitpur, Assam	[80]
29	*Hibiscus rosa-sinensis*	Joba	Malvaceae	Leaf	Sonitpur, Assam	[80]
30	*Zingiber officinalis*	Ada	Zingeberaceae	Rhizome	Sonitpur, Assam	[80]
31	*Curcuma amada*	Amda	Zingiberaceae	Rhizome	Sonitpur, Assam	[80]
32	*Adnentherapavonia*	Lalchandan	Fabaceae	Seed	Sonitpur, Assam	[80]
33	*Calotropis gigantean*	Akan	Asclepiadaceae	Leaf	Sonitpur, Assam	[80]
34	*Toddalia asiatica*	Jalukbon, Tezmui	Rutaceae	Fruits, Leaves	Sibsagar, Assam	[83]
35	*Zanthoxylum acanthopodium*	Lemon paper	Rutaceae	Plant	Shillong, Meghalaya	[84]
36	*Aristolochiasaccata*	Belikol, Chohu	Aristolochiaceae	Root	Sonitpur, Assam	[78]
37	*Annona squamosa*		Annonaceae	Leaf	Sonitpur, Assam	[78]
38	*Gymnopeteclumcochinchinensis*		Cucurbitaceae	Fruit/ Pericarp	Sonitpur, Assam	[78]
39	*Caesalpinea species*		Fabaceae	Bark	Sonitpur, Assam	[78]
40	*Piper species*	Jaluk	Piperaceae	Stem	Sonitpur, Assam	[78]
41	*Zanthoxylum limonella*		Rutaceae	Pericarp	Sonitpur, Assam	[85]

42	*Zingiber officinale*	Ada	Zingberaceae	Leaf	Sonitpur, Assam	[85]
43	*Curcuma longa*	Haladhi	Zingiberaceae	Leaf	Sonitpur, Assam	[85]
44	*Cumbopogoncitratus*		Poaceae	Leaf	Sonitpur, Assam	[85]
45	*Gloriosa superba*	Agnisikha	Liliaceae	Leaf	Sonitpur, Assam	[86]
46	*Hiptagebenghalensis*	Kerek-lota	Malpighiaceae	Root	Cherhlun, Mizoram	[87]
47	*Ageratinaadenophora*		Asteraceae	Leaf	Aizal, Mizoram	[88]
48	*Ipomoea cairica*		Convolvulaceae	Leaf, Flower	Aizal, Mizoram	[88]
49	*Aegle marmelos*	Bael	Rutaceae	Leaf	Nalbari, Assam	[74]
50	*Lippa alba*	Pikhachi Bon	Verbenaceae	Leaf	Jalukbari, Guwahati, Assam	[82]
51	*Allium sativum*	Naharu	Liliaceae	Bulbs	Barpeta, Assam	[34]
52	*Citrus grandis*		Rutaceae	Leaf, Peels	Barpeta, Assam	[34]
53	*Ocimum sanctum*	Kola-tulasi	Lamiaceae	Leaf	Barpeta, Assam	[34]
54	*Cirtus grandis*		Rutaceae	Fruits, Leaf	Barpeta, Assam	[89]

Future prospective

Mosquito borne diseases are one of major human health problem in all tropical and subtropical countries. To overcome problems developed by the chemical insecticides, botanicals has been included in pest control program in recent times. However, only a few numbers of such botanicals have come to field for its light and heat instability of phytochemicals as compared to synthetic insecticides. The activity of some single constituent compound of botanicals are promising but the synergistic combinations of different compounds may exert more insecticidal effect as mentioned in earlier studies. Thus, isolation and mass synthesis of bioactive botanical compounds provide a promising solution for the control of different mosquito borne diseases. Already preliminary investigation of different botanicals was done worldwide and most of them were recorded with noticeable effect. In this scenario, NE India holds a good position for its rich biodiversity and in future it may act as a great reservoir of botanicals which can be integrated in the vector control program.

Conclusion

The repeated use of chemical insecticides has led to the search for safer alternative as mosquitoes are developing resistance against it and also it causes various side effects to non-target organisms as well as the surrounding environment. Plants are rich source of bioactive organic chemicals and offer an advantage over synthetic pesticides as these are less toxic, less prone to development of resistance, and easily biodegradable. Screening and identification of effective plant compounds available in North-Eastern region of India will certainly bring more success towards the control of vector mosquito population.

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