

## Plant Origin Repellents and Insecticides

Insecticidal and repellent properties of some plants to mosquitoes are well-known. Phytochemicals obtained from huge diversity of plant species are an important source of safe and biodegradable chemicals, which could be screened for mosquito repellent and insecticidal activities.

### *Neem Oil as Mosquito Repellent*

*Azadirachta indica* commonly known as neem in India, has been used in various ways since ancient times. Dried neem leaves are commonly used in villages for protection against infestation of stored grains and other products by insects. Smoke produced by burning of neem leaves is used for the protection against mosquitoes. Neem oil has also been used in various insecticidal and medicinal preparations, but its mosquito repellent activity is not known. Therefore, systematic studies were undertaken at MRC to see the mosquito repellency of neem oil.

### *Topical Applications*

Repellent action of neem oil was evaluated against different vector species of malaria—*An. culicifacies*, *An. stephensi*, *An. minimus*, *An. fluviatilis* and *An. sudaicus* in the villages of Mandla district (M.P.), Ghaziabad district (U.P.) and Hardwar district (Uttaranchal), Kheda district (Gujarat), Panaji (Goa), Madras (Tamil Nadu), Car Nicobar (Andaman & Nicobar Islands) and Sonapur (Assam). Various concentrations of neem oil (1 to 4%) were prepared by mixing it with coconut oil/mustard oil. Two to five ml of neem oil was applied to the exposed body parts of the human volunteers. Protection against mosquitoes varied from place to place and species to species. These results have been summarized in Table 2. Vanishing cream with 5% neem oil was also prepared in collaboration with Department of Pharmaceuticals, Jamia Hamdard. Results revealed that neem cream provides 67 to 100% protection against malaria mosquitoes in different ecological terrains (Dua *et al.*, 1995, Singh *et al.*, 1996 & Nagpal *et al.*, 2001). Besides the field evaluation of the neem cream against the mosquitoes at Delhi, assessment of community (n = 102) acceptance was also done and results revealed that 92% showed preference for the cream because of (i) its easy application; (ii) pleasant odour; (iii) mosquitoes were repelled effectively up to 4 hours after the application; (iv) safety, no adverse reaction; and (v) better than any other cream. Application of neem oil is safe and, therefore, it can be used as a personal protection measure against mosquito bites.

### *Neem Oil Mats and Lamps as Mosquito Repellents*

Encouraged by the efficacy of neem oil as mosquito repellent, other methods of using neem oil were developed and evaluated by MRC (Sharma *et al.*, 1993 & Sharma and Ansari, 1994). Neem oil soaked mats 5 and 10% were tested as mosquito repellents in a village of Delhi. Results revealed that mean

**Table 2. Repellent activity of various herbal products against mosquitoes and sandflies**

Plant species	Plant product	Species tested	% Protection	References
<i>Azadirachta indica</i>	5–40%	<i>An. culicifacies</i>	80–100	Sharma <i>et al.</i> , 1993a
	Neem oil - mixed with coconut/ mustard oil as topical application	<i>Cx. quinquefasciatus</i>	61–100	Mishra <i>et al.</i> , 1995
		<i>Ae. aegypti</i>	85	Sharma <i>et al.</i> , 1995
				Rajnikant and Bhatt, 1994
		<i>Phlebotomus papatasi</i>	97.6	Dhiman and Sharma, 1994
		<i>Phlebotomus argentipes</i>	100	Sharma and Dhiman, 1993
	5% Neem oil in a cream-base topical application	<i>Ae. aegypti</i>	84	Dua <i>et al.</i> , 1995
		<i>Ae. albopictus</i>	78	Singh <i>et al.</i> , 1996
		<i>Anopheles</i> spp	93–100	
	5-10% Neem oil-impregnated on mats (Vapours)	<i>Culex</i> spp	89–94	Nagpal <i>et al.</i> , 2001
<i>Anopheles</i> spp		98	Sharma <i>et al.</i> , 1993	
1% Neem oil in Kerosene oil (Smoke)	<i>Cx. quinquefasciatus</i>	63		
	<i>An. culicifacies</i>	99–100	Sharma and Ansari, 1994	
<i>Cymbopogon</i> spp	Oil as topical application	<i>Culex</i> spp	79–81	Valecha <i>et al.</i> , 1996
		<i>An. culicifacies</i>	99–100 for 10 h	Ansari and Razdan, 1995
<i>Lantana camara</i>	Methanol + Coconut oil extract	<i>Cx. quinquefasciatus</i>	95–97 for 6 h	
		<i>Ae. albopictus</i>	94 for 2 h	Dua <i>et al.</i> , 1996
<i>Mentha piperita</i> essential oil	Steam distilled	<i>Ae. aegypti</i>	50 for 4 h	
		<i>An. annularis</i>	100	Ansari <i>et al.</i> , 1999
		<i>An. culicifacies</i>	92	
		<i>Cx. quinquefasciatus</i>	85	

catch per night per person in case of *Cx. quinquefasciatus* was 129.7 with 5% mat, 124.9 with 10% mat and 187.6 with commercially available mat (containing allethrin) as compared to 729.8 in the control (no mat). Smoke produced by burning neem oil mixed in kerosene oil in lamps had also shown protection from mosquito bites (Sharma and Ansari, 1994).

#### Other Herbal Products as Mosquito Repellents

In the past two decades various indigenous plants/products, in addition to the neem (*Azadirachta indica*) have been tested as mosquito repellents at Malaria Research Centre (Table 2). Oils of *Cymbopogon martini martini*, *Cymbopogon citratus* and

*Cymbopogon nardus* provided more than 95% protection against *Culex quinquefasciatus* and *An. culicifacies* in whole night landing collection on human baits (Ansari and Razdan, 1995). Flowers of *Lantana camara* extracted in methanol and mixed with coconut oil provided 94.5% protection against *Ae. albopictus* for two hours. Four fractions namely MRC-HR1, HR2, HR3 and HR4 were isolated from *Lantana* flowers using solvent extraction and chromatographic methods. Of these, MRC-HR2 showed maximum repellency against *Aedes* mosquitoes with a mean protection time of 2.43 hours. Repellent action of MRC-HR2 gave 85% protection up to 6 hours against *Aedes* sp in field conditions (Dua *et al.*, 1996).

Essential oil extracted by steam distillation of *Mentha piperita* provided 84.5–100% protection against *Cx. quinquefasciatus* and *An. culicifacies* during the whole night landing collection (Ansari *et al.*, 1999).

#### Larvicidal Activity of Herbal Products

Besides repellency effect, various plant products have also been tested for the insecticidal activities against mosquito larvae and adult stages (Table 3). In addition to the mosquito repellent action, neem (*Azadirachta indica*) oil and other commercial preparation of neem have also been found as potential mosquito larvicide (Mittal *et al.*, 1995). Neem oil produced immediate mortality as well as delayed effect by larval growth inhibition. Control of mosquito

breeding was demonstrated in small habitats using indigenous methods of application of neem oil in water and neem oil coated on wooden scraps (Batra *et al.*, 1998 & Nagpal *et al.*, 1995). Wood scrap balls soaked in 5, 10 and 20% neem oil in acetone were tested in overhead tanks of 0.50 m<sup>3</sup> in Ayurvigyan Nagar, Delhi against *An. stephensi* breeding. Each ball approximately weighed 10 g and contained 10 ml of neem solution. It was found that any concentration (5, 10 and 20%) of neem oil or any number (2, 4, 6) of balls does not prohibit egg laying but it arrests pupal formation and eventually the adult emergence for about 45 days. The results also revealed that two balls of 5% neem oil solution produced the best result.

**Table 3. Larvicidal activity of various herbal products against vector mosquitoes**

Plant species	Plant product	Species tested	References
<i>Calotropis procera</i>	Latex	<i>Cx. quinquefasciatus</i> <i>An. stephensi</i> <i>Aedes aegypti</i>	Girdhar <i>et al.</i> , 1984
<i>Mentha piperita</i>	Essential oil	<i>Cx. quinquefasciatus</i> <i>An. stephensi</i> <i>Ae. aegypti</i>	Ansari <i>et al.</i> , 1999
<i>Azadirachta indica</i>	Neem oil Neemmark Neemrich	<i>Cx. quinquefasciatus</i> <i>An. stephensi</i> <i>Ae. aegypti</i>	Sharma, 1993 Mittal <i>et al.</i> , 1995
	Neem oil-water emulsion Neem oil coated on wood scrappings	<i>Cx. quinquefasciatus</i> <i>An. stephensi</i> <i>Aedes aegypti</i> <i>An. stephensi</i> <i>Ae. aegypti</i>	Batra <i>et al.</i> , 1998 Nagpal <i>et al.</i> , 1995
<i>Tagetes erecta</i>	Steam distilled essential oil	<i>Cx. quinquefasciatus</i> <i>Ae. aegypti</i> <i>An. stephensi</i>	Pathak <i>et al.</i> , 2000
<i>Ocimum sanctum</i>	Steam distilled essential oil	<i>Cx. quinquefasciatus</i> <i>Aedes aegypti</i> <i>An. stephensi</i>	
<i>Murraya koengii</i>	Steam distilled essential oil	<i>Cx. quinquefasciatus</i> <i>Ae. aegypti</i> <i>An. stephensi</i>	
<i>Solanum nigrum</i> Linn.	Leaf extract	<i>An. culicifacies</i> <i>Cx. quinquefasciatus</i> <i>Ae. aegypti</i>	Singh <i>et al.</i> , 2001

Besides neem oil, Latex of *Calotropis procera* produced 100% mortality of larvae of *An. stephensi*, *Cx. quinquefasciatus* and *Ae. aegypti* at 1% concentration (Girdhar *et al.*, 1984). Steam distilled oil extract of *Tagetes erecta*, *Mentha piperita* and *Ocimum* produced 100% mortality against mosquito larvae of *An. stephensi*, *Cx. quinquefasciatus* and *Ae. aegypti* at doses lesser than 100 ppm (Pathak *et al.*, 2000). Crude extract of leaves of *Solanum nigrum* in water showed larvicidal activity against *An. culicifacies*, *Culex quinquefasciatus* and *Ae. aegypti* at a dose equivalent to LC<sub>90</sub> ranging between 0.18 and 0.21% (Singh *et al.*, 2001).