

Evaluation of repellent action of *Cymbopogon martinii martinii* Stapf var *sofia* oil against *Anopheles sundaicus* in tribal villages of Car Nicobar Island, Andaman & Nicobar Islands, India

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A field study was carried out to evaluate the mosquito repellent action of *Cymbopogon martinii martinii* Stapf var *sofia* oil in tribal village of Car Nicobar Island. Results revealed that application of 1 ml of the oil provided 98.7% protection in indoor and 96.52% in outdoor conditions during 12 h period of observation from the bites of *An. sundaicus*. *Cymbopogon martinii martinii* Stapf var *sofia* oil is an indigenous product, its application is safe and can be widely used for protection from malaria.

Key words *An. sundaicus* – malaria – mosquito repellent – palmarosa

Mosquito borne diseases such as malaria, filaria, dengue, yellow fever and encephalitis are continuing to be major health problems for the people in tropical countries¹. Mosquitoes alone transmit disease to more than 700 million people annually². Malaria kills three million people annually, including one child every 30 sec^{3,4}. Therefore, protection from mosquito bites is one of the best strategies to reduce the disease or reduce the incidence. Protection from mosquito bite can be achieved by avoiding mosquito prone habitats, wearing protective clothes and using mosquito repellents^{5,6}. Mosquito repellents become a viable practical alternative for floating population. In certain circumstances, applying repellent to the skin may be the only feasible way to protect against mosquito bites.

Since mid-1950s N, N-diethyl-m-toluamide, now called N, N-diethyl-3-methylbenzamide (DEET) has

been regarded as the standard mosquito repellent. Recently, Qiu *et al*⁷ reviewed the pharmacokinetics, formulations and safety of DEET. It exhibits a good margin of safety but does manifest some adverse effects in humans. A variety of oils extracted from plants also act as strong repellent for mosquitoes⁸. In order to find out the safer and more acceptable repellents, we have evaluated the repellent action of *Cymbopogon martinii martinii* Stapf var *sofia* oil against *An. sundaicus*. Results of this study are presented in this paper.

Material & Methods

Study area : Car Nicobar is a small flat island situated in the southeast corner at 6–100° north latitude and 92–94° east longitude in the Bay of Bengal, with an area of 127 km². The island is made up of corals. There are seven live creeks in this island of which Kimious creek is 1200 ha. There are several water bod-

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ies and marshy areas created during monsoon which remains up to nine months after the rainfall. About 60% of the Island is covered with forest. The Island situated in the tropics has hot and humid weather. Temperature varies from 25–30°C and relative humidity from 70–90%. The island receives both south-east monsoon from May–October and northeast monsoon from November–April. The annual rainfall varies from 2500 to 4000 mm. The climate of Car Nicobar Island provides an ideal environment for mosquito breeding and proliferation due to high rainfall associated with hot and humid conditions. The inhabitants of this Island are Nicobarese who are of Mongoloid origin and live in huts made up of woods, bamboo and leaves.

The repellent action of *sofia* oil was tested in Kimious village of Car Nicobar Island. This experimental village has several larval mosquito habitats producing large *An. sondaicus* population and is endemic for malaria. *An. sondaicus* is the only vector responsible for malaria transmission in Andaman and Nicobar group of islands⁹⁻¹². Mosquito densities were monitored at fortnightly intervals by hand catch method in four rooms and four cattlesheds. The average annual man hour density of *An. sondaicus* ranged from 21.14–52.55. *An. barbirostris* was encountered occasionally during collections.

Cymbopogon martinii martinii Stapf var *sofia* oil: *Cymbopogon martinii martinii* Stapf var *sofia* (Poaceae) is a wild perennial shrub, commonly known as Palmarosa, a relative of lemon grass and Citronella. The plant grows wild in India and Pakistan. Palmarosa essential oil is used in the perfume industry as a fragrance ingredient in India.

Pure oil of var *sofia* was obtained from Plant Genetic Resource Division, Indian Agriculture Research Institute, New Delhi. Palmarosa oil consists of geraniol (76.15%), geranyl acetate (9.05%), linalool (3.86%), limonene (1.74%), nerol (1.53%), elemol (1.45%), Y. terpinene (0.49%) and myrcene (0.07%)¹³. The oil is obtained from the leaves of the

plants either fresh or dried by the process of steam distillation.

One ml of pure oil was applied on the exposed body parts (face, arms and legs) of volunteers at 1800 hrs and allowed to sit and relax on a cot throughout the night. Simultaneously, untreated (control bait) was also allowed to rest throughout the night. Informed and free consent was obtained from the volunteers for the present study. Mosquitoes were collected from 1800–0600 hrs for 10 nights each indoor and outdoor bait collections. For all night collection, a volunteer served as bait from 1800–2400 hrs and was replaced by another volunteer until 0600 hrs. Mosquitoes landing on treated and untreated volunteers were collected throughout the night with the help of a suction tube and a flash light by insect collectors. Insect collectors were rotated at an interval of six hours to avoid bias collections. Mosquitoes collected on baits were identified in the laboratory under a Stereozoom microscope. The site of each type of bait was interchanged to prevent biasness of the collection. Relative efficacy was tested for 10 nights each in indoor and outdoor. Per cent protection from man-mosquito contact was calculated by the following formula:

$$\% \text{ Protection} = \frac{(\text{No. of mosquitoes in control group}) - (\text{No. of mosquitoes in experimental group})}{\text{No. of mosquitoes in control group}} \times 100$$

Results & Discussion

Several plants have been tested as potential botanical sources of insect repellents¹⁴⁻¹⁶. The plant based insect repellents currently sold in the market contain essential oil of the following plants—Citronella, Cedar, Eucalyptus, Peppermint, Lemongrass, Geranium and Soybean.

The results of the repellent action of *Cymbopogon martinii martinii* var *sofia* oil on human volunteers against *An. sondaicus* are given in Table 1. Results clearly showed that application of *Cymbopogon mar-*

Table 1. Efficacy of *Cymbopogon martinii martinii* var *sofia* oil in repelling *An. sundaicus* based on human bait collection*

Observation time (hrs)	Indoor			Outdoor		
	Experimental	Control	% Protection	Experimental	Control	% Protection
1800–1900	0	19	100	0	22	100
1900–2000	0	38	100	0	33	100
2000–2100	0	42	100	0	38	100
2100–2200	0	62	100	0	61	100
2200–2300	0	75	100	0	77	100
2300–2400	0	79	100	3	108	97.22
2400–0100	2	76	97.36	5	122	95.90
0100–0200	1	30	96.66	4	53	92.45
0200–0300	2	26	92.30	4	32	87.50
0300–0400	1	15	93.33	3	23	86.95
0400–0500	0	1	100	1	7	85.71
0500–0600	0	0	0	0	0	0
Total/Average	6	463	98.70	20	576	96.152

* No. of mosquitoes collected in night collections each indoor and outdoor.

Table 2. Landing rate of *An. sundaicus* on *C. martinii martinii* var *sofia* oil treated and untreated volunteers (both indoor and outdoor) from dusk–to–dawn

Place of collection	Females landed on treated/untreated human baits (hrs)												Total	Complete protection time (h)
	1800 to 1900	1900 to 2000	2000 to 2100	2100 to 2200	2200 to 2300	2300 to 2400	2400 to 0100	0100 to 0200	0200 to 0300	0300 to 0400	0400 to 0500	0500 to 0600		
	Indoor	0/19	0/38	0/42	0/62	0/70	0/79	2/76	1/25	2/26	1/25	0/1		
Outdoor	0/22	0/33	0/38	0/61	0/77	3/108	5/122	4/53	4/32	3/23	1/7	0/0	20/576	6

Total of 10 replicates each indoor and outdoor.

tinii martinii var *sofia* oil provides 98.7% protection in indoor and 96.52% protection in outdoor conditions against the bites of *An. sundaicus* respectively for 12 h. The landing rate of *An. sundaicus* on treated and untreated human volunteers at different time intervals is shown in Table 2. Results revealed that protection time varied in *An. sundaicus*. Single application of the oil resulted in protection from *An. sundaicus* bite for eight hours in indoor and six hours in out-

door respectively. Studies carried out by Ansari and Razdan¹⁷ revealed that the *Cymbopogon martinii martinii* var *sofia* oil provided absolute protection for 1200 hrs against *An. culicifacies* and similar degree of protection was evident against *An. annularis* and *An. subpictus*.

However, multiple factors play part in determining the effectiveness of any repellent. These include the spe-

cies of the biting organism, the users age, sex, level of activity and biochemical attractiveness to the biting mosquitoes and ambient temperature, humidity and wind speed¹⁸⁻²¹. Therefore, a repellent may not protect all users equally. Thus the time of protection should be taken as an indication of the relative effectiveness of the tested repellent. *Cymbopogon martinii martini* var *sofia* oil produced a strong repellent action against *An. sundaicus*.

Study revealed that the oil of *Cymbopogon martinii martinii* var *sofia* oil could be used to repel *An. sundaicus* in both indoor and outdoor, which is the only vector responsible for the malaria transmission in Andaman and Nicobar Islands. The oil of *Cymbopogon martinii martinii* var *sofia* oil is a non-sticky with rose like aroma. It is non-toxic, non-sensitising and non-irritant. Palmarosa oil is very useful in skin care. It helps regulate the production of sebum, moisturises dry skin, reduces wrinkles and improve the skin tone and appearance.

Repellent action of *C. nardus* and *C. citrates* oil is well-known for the repellency of house flies and mosquitoes^{22,8}. Topical application of oil on the exposed body parts is a common practice among the Nicobarese. Therefore, the use of *Cymbopogon martinii martinii* var *sofia* oil among the Nicobarese people within the socio-cultural practice will increase the application of Palmarosa oil vis-a-vis control malaria.

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