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Insecticides susceptibility status of dengue vector, *Aedes aegypti* in NCR Delhi, India

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Abstract
Aedes aegypti plays a key role in dengue transmission, as a principal vector. The vector species have progressively started to developed resistance against most of the currently used insecticides. Hence, a study was carried out in dengue endemic areas of NCR during 2018 to find out the current situation of insecticide susceptibility status of *Aedes aegypti* against various insecticides under ambient room temperature of 28±2 ^{0}C and relative humidity at 70±5%. The results revealed that adult *Ae. aegypti* was resistant to DDT, tolerant to Malathion and susceptible to Deltamethrin. However, the larvae were found to be susceptible to Temephos and Diflubenzuron.

Keywords: *Aedes aegypti*, susceptibility, intermediate resistance, dengue vector NCR, insecticide

Introduction
Dengue is a major public health concern throughout the tropical and subtropical regions of the world. The World Health organization (WHO) estimates that 50-100 million dengue infectious occur each year and that almost half the world population lives in countries where dengue is endemic. It has been identified as one of the 17 neglected tropical diseases by WHO.
In India, *Aedes aegypti* is widely distributed and plays a key role in dengue transmission as a principal vector. Now this vector has spread to rural areas and spreading in areas which were so far free from this disease. Vector control is the main way to check dengue transmission, until a prospective vaccine against DENV is available for prevention of dengue fever [1]. Insecticides play an important role in vector control for the control of dengue. In case of Aedes mosquito vector control is mainly confined to larval control [2]. Control of adult dengue vectors by thermal fogging is only recommended in response to dengue outbreaks. The evolution and spread of resistance to insecticides is a major concern for the control of all arthropod transmitted infections and dengue is no exception among them [3].
Resistance in vectors is monitored by insecticide susceptibility tests designed by WHO [4]. It is helpful in formulating the control strategies for the disease containment
But, resistance to insecticides has appeared in major insect vectors from every genus, and this is expected to directly and profoundly affect the re-emergence of vector-borne disease [5].
Although progress is being made on vaccine, vector control by removing larval habitats and using biological and chemical insecticides still remain the first line of defense against arboviruses [6]. Control of adult mosquitoes using space spray application of pyrethroids and organophosphates in plural is fraught with complications, including high cost, slow operational response, ineffective timing of applications and rather low efficacy and/or residual effect [7, 8]. Therefore, the current study was designed to assess the susceptibility status of dengue vectors in NCR Delhi.

Materials and Methods
Study area
The study area was selected on the basis of having high prevalence rate and outbreak of dengue infection. The study was carried out in 5 localities of Noida (NCR which include Bhangel Phase II, Harola, Nithari, Baraulla and Raghunathpur) where abundance of construction activities and increased mobility of population have added to the dengue transmission. Bhangel Phase II, Harola and Nithari are densely populated and the nearest urban areas are Noida's Sector 93, Sector 5 and Sector 31 respectively where construction

under different builders have been tremendous in recent past. Barolo, a huge village with population of more than one lakh has Noida's upscale sectors 47, 48, 50 and 51 as its boundaries. Similarly, Raghunathpur has Sector 22 as nearest urban area which is having a population of nearly 30,000.

Adult mosquitoes emerging form the field-collected larvae and pupae under laboratory conditions were allowed to feed on 10% glucose solution soaked in cotton pads. The insecticide susceptibility test was done during 2018 in accordance with the guidelines laid down by the WHO standard procedures.

Different insecticides like Organochlorine (DDT-4%), Organophosphate (Malathion -5%) and Pyrethroid (Deltamethrin – 0.05%) were used against one-to-two-day-old mosquitoes collected from different locations of NCR. After the requisite exposure period, the mosquitoes were transferred to recovery chamber and cotton pads soaked in 1% glucose solution was given as food during the recovery period. Control replicates were also held parallel to each test. The mortality was calculated after 24 hours. The recovery period was used for determining the susceptibility / resistance status.

For larval susceptibility test III and IV stages larval collected from the field were separated and were washed in tap water and kept under observation for the period of 24 hours to detect and remove unhealthy or dead larvae. The larvae were tested against the discriminating doses dosages of larvicides viz. Temephos (0.02 mg/L), Diflubenzuron (0.025 mg/L). Brewer's yeast was given as food during the treatment period. The mortalities were calculated after 24 hours of recovery period.

The adult and larval tests showing more than 20% control mortality were discarded and repeated. In case control mortality ranged from 5% to 20%; the corrected mortality was calculated using Abbot's Formula (Abott 1925) [9] according to the guidelines of WHO.

Results

The results of the adult susceptibility test revealed that *Aedes aegypti* species was resistant to DDT as only 21.5% mortality could be obtained. Discriminating dosages of Malathion caused 86% mortality indicating tolerance of the species to this insecticide. Exposure of adults to the discriminating dosages of Deltamethrin induced 98% mortality indicating that the species was susceptible to these insecticides. (Table 1)

Table 1: Results of susceptibility tests against *Aedes aegypti* using various Insecticides under laboratory conditions

Insecticide	Discriminating dosages %(mgm/ ltr)	No. of Adult mosquitoes exposed		No. of Mosquitoes Died		percent Mortality obtained	Susceptibility Status
		Test	Control	Test	Control		
DDT	4.0	200	50	43	2	21.5	R*
Malathion	5.0	200	50	172	1	86	T**
Deltamethrin	0.05	200	50	196	2	98	S***

R*-Resistant; T**- Tolerant S***-Susceptible

When the *Aedes aegypti* larvae were exposed to discriminating dosages of Temephos and Diflubenzuron, 98-99% mortality of larvae was detected. It shows that *Aedes aegypti* larvae were susceptible to both Temephos and Diflubenzuron. (Table 2)

Table 2: Results of susceptibility tests carried out against larvae of *Aedes aegypti* using various larvicides under laboratory condition

Insecticide	Discriminating dosages used in percent (mgm/per ltr)	No. of Larvae exposed		No. of Larvae Died		percent Mortality obtained	Susceptibility Status
		Test	Control	Test	Control		
Diflubenzuron	0.025	100	25	98	0	98	S*
Temephos	0.02	100	25	99	0	99	S*

S* - Susceptible

Discussion

Aedes aegypti has developed a strong resistance to commonly used adulticide and larvicide which necessitates continuous susceptibility monitoring for effective vector control programme. Insecticide resistance management (IRM) is crucial to maintain vector control sustainable. Studies have been undertaken by earlier investigators to assess insecticidal susceptibility status against dengue vectors in different parts of India [10, 11, 12].

Temephos is organophosphate insecticide which is still effective as larvicide for controlling Aedes mosquito larvae. [13]. Widespread use of Temephos has led to the development of resistance in different countries, including Thailand [14], Brazil [15]. Tolerance/ resistance against Temephos is reported from the field collected larvae in Delhi [1631].

In the laboratory, the aquatic stages of *Ae. aegypti* developed induced resistance to Temephos, which showed varying degree of cross resistance to Fenthion, Malathion and DDT. The expression of Temephos induced larval resistance was also observed in adult stages [17]. The immature of *Aedes* mosquito have shown the tendency of developing induced resistance to Temephos under laboratory conditions [18]. Our study is consistent with the study carried out in Ranchi city, Jharkhand and Assam in which immature stages is still susceptible to Temephos, Fenthion and Malathion [19, 20]. DDT resistance in *Ae. aegypti* was recorded for the first time in Jharia [21], Bihar and others also reported the resistance of the species to DDT in different parts of the country [22, 23, 24, 25, 2631].

In southern India, *Ae. aegypti* was resistant to DDT and Di-eldrin but susceptible to Propoxin, Fenitrothion, Malathion, Deltamethrin, Permethrin and Lambdacyhalothrin [27] which is consistent with our study against Adult *Ae. aegypti* in NCR. Previous studies conducted in different parts of India have reported varying degree of resistance towards DDT and Pyrethroid [28, 29, 30]. In bioassay method, 100% Adult *Ae. aegypti* mosquitoes were found to have resistant against DDT, about 8% showed resistance against Pyrethroid and 4% towards Malathion [31].

Conclusion

From the study it is concluded that *Aedes aegypti* prevalent in NCR, India have progressively started to developed resistance capability towards currently used insecticides which may bring an indication of major dengue outbreaks in NCR. There is a need to test the insecticides susceptibility status time to time to monitor and manage resistance to insecticides used in public health for the prevention and control of dengue outbreak.

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