SEASONALITY AND INSECTICIDE SUSCEPTIBILITY OF DENGUE VECTORS: AN OVITRAP BASED SURVEY IN A RESIDENTIAL AREA OF NORTHERN SRI LANKA

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Abstract. With the backdrop of a high incidence of dengue in Jaffna District, Sri Lanka, an ovitrap based survey was carried out from May 2005 to April 2006 in a residential area to study the seasonality and insecticide susceptibility of *Aedes aegypti* and *Ae. albopictus*. Conventional ovitraps were placed inside and outside of 10 randomly selected houses to collect indoor breeding and outdoor breeding *Aedes* mosquitoes; collections took place fortnightly. A total of 3,075 *Ae. aegypti* and 2,665 *Ae. albopictus* were collected in outdoor ovitraps, whereas in indoor ovitraps a total of 2,528 *Ae. aegypti* and 2,002 *Ae. albopictus* were collected. The highest values for *Aedes* density and positive ovitrap percentage were recorded in January 2006. A seasonal shift was observed in the density of *Ae. aegypti* and *Ae. albopictus*. *Ae aegypti* density was high during and after the Northeast monsoon whilst *Ae. albopictus* was the dominant species during the onset of the Northeast monsoon. A significant association ($p<0.05$) between *Aedes* density and rainfall was observed. The association of these two species to site, either indoors or outdoors, was not statistically significant ($p>0.05$). Both the species were found to be highly resistant to 4% DDT and completely susceptible to 5% malathion. The high prevalence and the ability of both species to breed indoors and outdoors should be taken into account when formulating a dengue vector control program with community participation in the Jaffna District, Sri Lanka.

INTRODUCTION

Dengue, a disease caused by arboviruses, remains a public health problem in Sri Lanka. A dramatic increase in the reported number of cases of dengue hemorrhagic fever (DHF) in Sri Lanka has been observed in recent years (Messer *et al*, 2002). In Jaffna District, having a population of nearly 0.58 million, 127 patients were confirmed to have DHF (Office of the DPDHS, Jaffna, personal communication) in the year 2003 (Table 1). *Aedes aegypti* Linnaeus and *Ae. albopictus* Skuse are incriminated as vectors of dengue in Sri Lanka (Vitarana *et al*, 1986 cited in Ramasamy *et al*, 1994). Data on the bionomics of these dengue vectors in Jaffna District are scanty owing to two decades of civil disturbances which have had a great influence on the day-to-day life of the people and the deliverance of health services in Jaffna District.

Vector surveillance is an essential component in the implementation of an optimum vector control program to combat dengue. The ovitrap is a sensitive and economic tool to detect and assess the population density of *Aedes* mosquitoes (WHO, 1994, 2003). In order to assess the prevalence in human dwellings and to monitor the insecticide susceptibility of *Ae. aegypti* and *Ae. albopictus* an ovitrap survey was carried out at Thirunelvely, a residential

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Table 1
Prevalence of dengue cases in the Jaffna District from 2002-2004 (source: DPDHS Office, Jaffna).

Year	Identified dengue cases	
	Jaffna District	Kopay Health Division (MOH)
2002	32	10
2003	127	29
2004	113	15

area in the Kopay Health Division, and the results are reported here.

MATERIALS AND METHODS

Study site

Thirunelvely (9º 40´ N: 80º 01´ E) is a highly populated suburban residential area. The adjacent environs of the study site are mainly agricultural crop lands. Houses in the close proximity to the main campuses of the University of Jaffna were selected randomly covering an area of about 2 km^2 (Fig 1).

Collection of *Aedes* mosquitoes

Conventional black plastic ovitraps (Service, 1976) were used to collect *Aedes* mosquitoes from 10 randomly selected houses. A total of 4 ovitraps (2 indoor and 2 outdoor) per house were placed in each selected house. In each house outdoor ovitraps were placed within 5 meters of the house with a minimum of 15 meters between the two ovitraps. The indoor ovitraps were placed 1 per livingroom in close proximity to shelves or racks or hanging cloths. Each coded ovitrap, with a capacity of 250 ml, contained 100 ml water and 3 x 10 cm plywood paddle resting against the upper rim. Collections were carried out fortnightly from May 2005 to April 2006 to cover the rainy and dry seasons. After collecting any laid eggs and hatched larvae, the ovitraps with replaced paddle were kept with the same amount of water in the same location for the next round of collection. Collected eggs and larvae from each coded ovitrap were brought to the laboratory and reared separately to become adults. Emerged *Aedes* adults were identified (Mahadevan and Cheong, 1974) and counted.

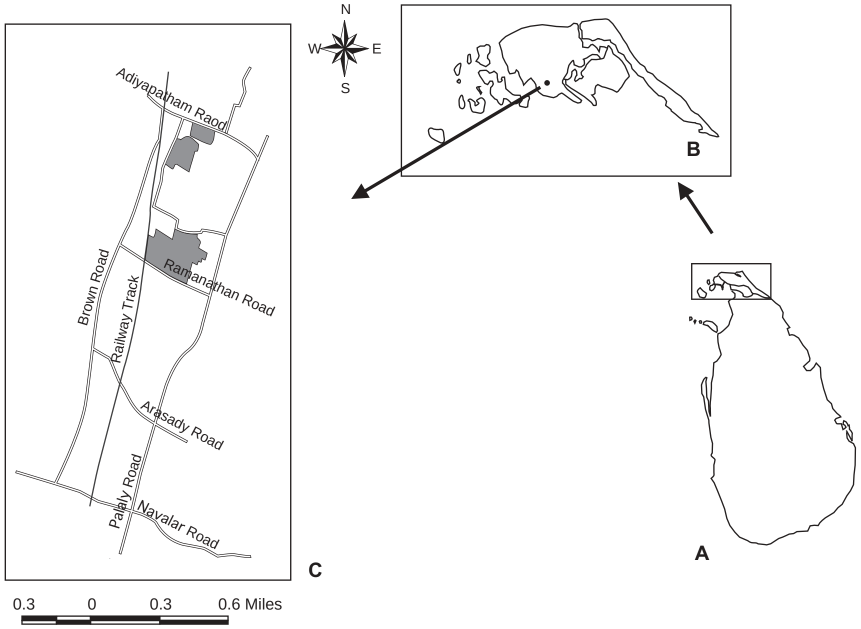

Fig 1–Study area (C) in Jaffna District (B) of Sri Lanka (A). (Shaded areas are the premises of the Jaffna University).

Susceptibility test to common insecticides

The WHO kit for susceptibility test (WHO, 1981) was used to test the emerged adults against the WHO recommended dosage of DDT (4%), and malathion (5%). The susceptibilities of 1-2 days old *Ae. aegypti* and *Ae. albopictus* were determined by exposing the adults in batches of 5-20 to insecticide impregnated paper (obtained through the Vector Control Research Unit, University Sains, Malaysia).

Meteorological data

Rain fall, temperature and relative humidity data were obtained from the Meteorological Department at Thirunelvely.

Analysis

The '*t*' test was performed to detect any differences between the indoor and outdoor breeding preferences of the collected *Aedes* mosquitoes. Regression analysis was done to correlate the *Aedes* density with rain fall. The percentage of positive ovitraps was also calculated.

RESULTS

Prevalence and breeding preferences of *Ae. aegypti* and *Ae. albopictus*

A total of 10,270 *Ae. aegypti* and *Ae. albopictus* specimens were collected during

Table 2
Monthly collection of *Aedes* mosquitoes in indoor and outdoor ovitraps.

Date of collection	Number of *Aedes* mosquitoes collected				Total *Aedes* collected	Total *Aedes* collected/month
	Indoor collection		Outdoor collection			
	Ae. aegypti	*Ae. albobictus*	*Ae. aegypti*	*Ae. albobictus*		
15.05.2005	21	12	137	27	197	
29.05.2005	47	88	30	81	246	443
12.06.2005	91	46	83	37	257	
26.06.2005	127	24	57	23	231	488
10.07.2005	81	98	68	74	321	
24.07.2005	136	41	47	61	285	606
07.08.2005	78	49	62	121	310	
21.08.2005	132	66	48	104	350	660
04.09.2005	76	112	50	98	336	
18.09.2005	70	33	14	23	140	476
02.10.2005	51	80	54	64	249	
16.10.2005	39	62	23	91	215	
30.10.2005	53	55	167	107	382	846
13.11.2005	83	74	136	300	593	
27.11.2005	217	116	157	216	706	1,299
11.12.2005	110	88	248	209	655	
25.12.2005	156	151	253	160	720	1,375
08.01.2006	115	171	246	149	681	
22.01.2006	145	172	281	137	735	1,416
05.02.2006	167	93	245	92	597	
21.02.2006	142	52	215	123	532	1,129
06.03.2006	165	92	96	103	456	
20.03.2006	98	141	78	85	402	858
03.04.2006	84	52	154	68	358	
17.04.2006	44	34	126	112	316	674
Total	2,528	2,002	3,075	2,665		10,270

the study period. In indoor ovitraps 2,528 *Ae. aegypti* and 2,002 *Ae. albopictus* specimens were collected, whilst 3,075 *Ae. aegypti* and 2,665 *Ae. albopictus* specimens were collected in outdoor ovitraps (Table 2). The prevalence of each species was recorded throughout the study period. The maximum of 95% for positive ovitraps was recorded during the month of January, 2006. All sampled houses had positive ovitraps, either indoors and/or outdoors. Whilst the peak density of *Ae. aegypti* and *Ae. albopictus* was recorded in January 2006 the lower prevalence of *Aedes* species was recorded during the dry season falling between March and August (Fig 2). Though *Ae. aegypti* was found to be the predominant species, constituting 55% of the total collection, in the study area the density of *Ae. albopictus* surpassed that of *Ae. aegypti* at the onset of the Northeast monsoon falling between August and November. During this period *Ae. albopictus* was found to be the predominant species collected in outdoor ovitraps (Fig 4A). A continuous dominancy of *Ae. aegypti* was observed on indoor collection except in the months of October and January (Fig 4B). Statistical analysis showed a positive association with *Aedes* density and rainfall ($p<0.05$) (Fig 3). However, the preference of both species to breed either indoors or outdoors was not statistically significant ($p>0.05$).

Susceptibility to common insecticides

Both species were found to be highly resistant to 4% DDT (organochloride) and completely susceptible to 5% malathion (organophosphate) (Table 4).

DISCUSSION

The present study reveals a high and continuous prevalence of *Ae. aegypti* and *Ae. albopictus*, the reported vectors of dengue in Sri Lanka in the residential area of Thirunelvely in Jaffna District. This is in contrast to a previ-

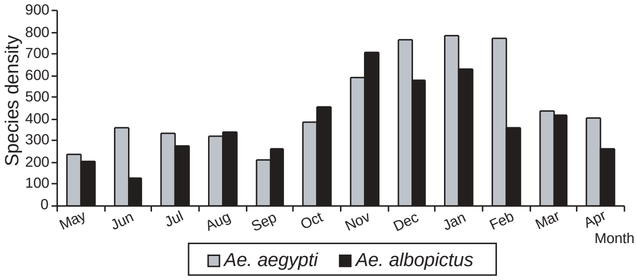

Fig 2–Monthly collection of *Ae. aegypti* and *Ae. albopictus* during the study period.

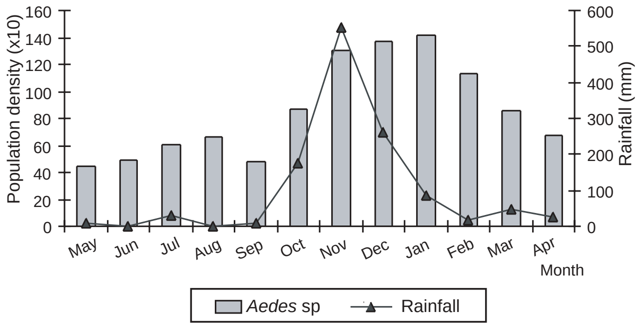

Fig 3–Monthly collection of *Aedes* mosquitoes in association with rainfall in the study locality.

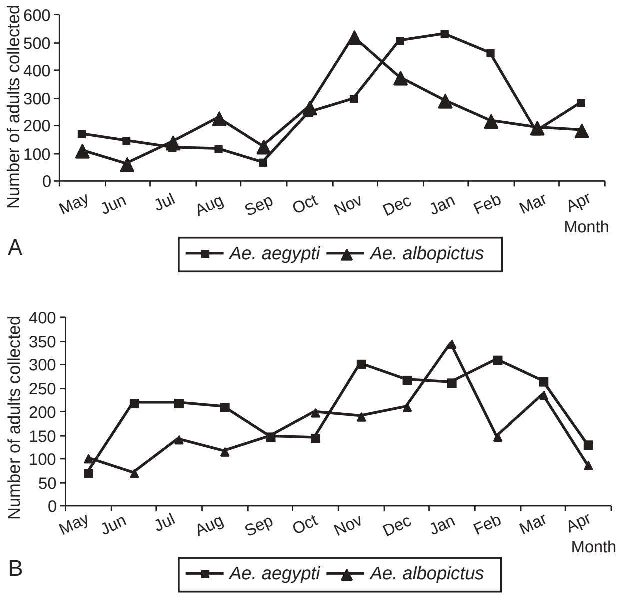

Fig 4–Monthly variation in the number adults collected in outdoor (A) and indoor (B) ovitraps.

Table 3
Number of ovitraps found with *Aedes* larvae in the sampled houses.

Date of collection	Number of positive ovitraps		% of positive ovitraps (out of 40)
	Indoor ovitraps (out of 20)	Outdoor ovitraps (out of 20)	
15.05.2005	5	15	50
29.05.2005	9	7	40
12.06.2005	11	9	50
26.06.2005	11	9	50
10.07.2005	12	13	62.5
24.07.2005	13	11	60
07.08.2005	8	13	52.5
21.08.2005	10	8	45
04.09.2005	15	12	62.5
18.09.2005	13	4	42.5
02.10.2005	11	10	52.5
16.10.2005	8	8	40
30.10.2005	10	16	65
13.11.2005	13	15	70
27.11.2005	16	15	77.5
11.12.2005	13	15	70
25.12.2005	13	15	70
08.01.2006	16	15	77.5
22.01.2006	18	20	95
05.02.2006	14	16	75
21.02.2006	16	12	70
06.03.2006	15	15	75
20.03.2006	7	9	40
03.04.2006	13	6	47.5
17.04.2006	8	11	47.5

Table 4
Resistance status of *Ae. aegypti* and *Ae. albopictus* to 4% DDT and 5% malathion.

Insecticide	% survival	
	Ae. aegypti	*Ae. albopictus*
DDT 4%	73% (126)[a]	77% (172)
Malathion 5%	0% (110)	0% (104)

[a]Figures in parenthesis denote number of adults exposed to the dosage.

ous study that reported a sporadic prevalence of these two mosquito species in Jaffna Peninsula (Rajendram and Antony, 1991). The occurrence of these two vector species is of public health importance since the prevalence of these vector species can be considered as one of the factors contributing to the high prevalence of dengue in the recent past in Jaffna District. In the year 2002, only 32 dengue patients were identified in the district. However, the figure increased almost four fold in the year 2003 and remained similar for the year 2004 (Table 1).

The Jaffna Peninsula generally experiences rainfall due to the Northeast monsoon from October to mid January and the rest of the season is fairly dry and humid. High densities of these two species recorded from November to January shows a significant association with monsoon rain. The lower prevalence of these species in the months of March to August may be due to the dry and humid conditions that reduce breeding grounds for mosquitoes (Table 5). Though the results show that *Ae. aegypti,* the reported vector in urban areas in Sri Lanka, was predominant in both indoor and outdoor samples in the locality the *Ae. albopictus* density surpassed that of *Ae. aegypti* at the onset of the Northeast monsoon, falling between August and November. This indicates a seasonal shift in the abundance of these two species. The two vector species co-exist in the same locality; the interspecific competition and/or the meteorological influences on the prevalences are yet to be established.

Fogging malathion in liquid form has been employed to control *Aedes* mosquitoes whenever there is a high incidence of dengue and/ or a high density of *Aedes* mosquitoes (DPDHS Office, Jaffna, personal communication) in the district. The fogging is not carried out routinely. The present insecticide susceptibility study reveals that both species are highly resistant to DDT and completely sus-

Table 5
Monthly rainfall and mean temperature of the study locality during the study period (source: Meteorological Department, Thirunelvely).

Year	Month	Rainfall (mm)	Mean temperature (ºC)	RH (%)
2005	May	8.2	30.5	72
2005	June	0	30.2	72
2005	July	30	29.3	74
2005	August	0	29.7	69
2005	September	8.2	29.6	64
2005	October	177	28.1	77
2005	November	554.9	25.9	86
2005	December	263.4	25.7	79
2006	January	87.6	25.3	75
2006	February	17.5	26.1	70
2006	March	45.5	28.1	69
2006	April	26.9	29.8	69

ceptible to malathion. The organochloride selection pressure might be due to the extensive application of DDT in the district for malaria control before 1972. However, the low organophosphate resistance which was introduced in Sri Lanka in 1972 (Karunaratne, 1999), can be linked to irregular insecticide spraying activities owing to two decades of civil disturbances in the northeast province of the country. A study of the susceptibility of *Ae. aegypti* and *Ae. albopictus* collected from different parts of the western province and northwestern province of the country revealed that both species have developed resistance due to acetylcholine esterase enzyme insensitivity to inhibition with insecticides, elevated glutathione-S-transferase enzyme activity and esterase based detoxification. The study further suggested that resistance of these two species could increase if organophosphate and carbamate are sprayed to control these vector species (Jayasooriya and Weerasinghe, 2004). There is no reported study of the susceptibilities of these two species to common insecticides from Jaffna District.

Mosquito abundance can be related to population and human activity (Okogun *et al*, 2003). All sampled houses having positive ovitraps is an indication of human activity that provides a suitable environment for the propagation of these vector species in this residential area. In Sri Lanka, breeding sites of these vector species are largely man made. The vector species prefer to breed in small collections of water in containers like discarded tires, coconut shells and husks, tins, bottles, gutters, and water storage containers (Vitarana, 1990; Srikrishnaraj *et al*, 2006). *Aedes* mosquitoes can also breed in high organic compound containing water environments, including polluted waters, soakage pits, septic tanks, domestic run-off and gutters (Vitarana, 1990). Proper environmental management, including adherence to basic architectural requirements, are essential to prevent sewage effluents and soakage pits in domestic water run-off from becoming breeding sites for dengue vectors (Okogun *et al*, 2003). The indoor breeding ability of these vector species in Jaffna District should be taken into account in formulating a dengue vector control program. One of the major components of the integrated vector control strategy is environmental modifications and manipulations which include the principle strategy of source reduction which refers to the drainage or removal of natural water sources or human-made water containers, rendering a condition which hinders the completion of the vector life cycle (Ault, 1994).

Since there is no well-established facilities to detect dengue in the Jaffna General Hospital, the immediate action is to control the vectors. This can be partly be achieved by eliminating all possible breeding sites. The public should also be advised to employ personal protective measures to prevent bites. The health authorities should continuously carry out surveillance, including monitoring dengue vector populations to prevent or reduce dengue risk. The prevalence of a high density of dengue vectors in this residential area, therefore, warrants an intensification of vector surveillance activities along with health education with community participation.

ACKNOWLEDGEMENTS

The following are gratefully acknowledged; Head, Department of Zoology, University of Jaffna for facilities; S Tharmasena, Department of Zoology for laboratory assistance; DPDHS. Jaffna for providing data regarding dengue cases; owners of the sampled houses for assistance and cooperation; Dr A Antonyrajan, Department of Geography, University of Jaffna for the study map; and the Director, Meteorological Department, Thirunelvely for providing meteorological data.

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