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## Prevalence and Seasonal Distribution of Dengue Mosquito, *Aedes aegypti* (Diptera: Culicidae) in Al-Madinah Al-Munawwarah, Saudi Arabia

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**Abstract:** *Aedes aegypti* (*Ae. aegypti*) is a cosmo-tropical, urban, peri-domestic mosquito, was established as the primary indigenous vector of recent urban dengue virus outbreaks in Jeddah and Makkah, Saudi Arabia. Dengue virus activity has never been reported in Al-Madinah. An entomological survey was carried out to document prevalence and seasonal distribution of *Aedes* mosquitoes for the first time in Al-Madinah Al-Munawwarah, Western Saudi Arabia. Adult *Aedes* were collected for a year from July 2008 to June 2009, using standardized sampling with overnight; Black Hole UV trap produces CO<sub>2</sub> and morning; knockdown Spray-sheet method. *Ae. aegypti* was the only identified *Aedes* mosquito species in all surveyed residential areas in Al-Madinah. A total of 463 *Ae. aegypti* adult mosquitoes were identified; 300 (64.8%) females and 163 (35.2%) males. It was abundant year round with varying density among months; it peaked at April. Density of *Ae. aegypti* intra-domiciliary was higher than extra-domiciliary stations and inflated by a greater proportion of female mosquitoes. Non-fed females were significantly outnumbered blood-fed females. These results necessitate further epidemiological surveillance and implicate regular strict monitoring of *Ae. aegypti* in Al-Madinah Al-Munawwarah, to overrule the possibility of *Ae. aegypti* establishment in Al-Madinah.

**Key words:** *Ae. aegypti*, Al-Madinah Al-Munawwarah, prevalence, seasonal distribution

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### INTRODUCTION

*Aedes aegypti* (Linnaeus, Diptera: Culicidae) is of considerable public health importance in the tropics and subtropics. *Ae. aegypti* mosquitoes are the most important and the primary domestic vector of urban dengue and yellow fever viruses (Gubler, 1988, 1998). It can transmit Chikungunya (Sam and Baker, 2006), Murray Valley encephalitis and Ross River (Lee *et al.*, 1987) viruses in addition to *Chandipura* virus (Rhabdoviridae) experimentally (Mavale *et al.*, 2005). *Aedes aegypti* can also transmit filarial infections of *Wuchereria bancrofti* and *Dirofilaria immitis* (Russell *et al.*, 2005), avian parasite

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*Plasmodium gallinaceum* (Alavi *et al.*, 2003). It can mechanically transmit Lumpy Skin Disease Virus (LSDV) from infected to susceptible cattle (Chihota *et al.*, 2001).

It is a cosmo-tropical, domestic mosquito, considered to be an urban mosquito exists inside and near human habitation and favor densely populated areas, but it also breeds in rural areas. Females are day biters have also been taken in lesser numbers at night (Christophers, 1960; Clements, 1999). They enter buildings to feed and prefer to lay their eggs in artificial water containers such as flower pots, vases, gutters, roof guttering, tires, bottles, tins, cans, pot plant saucers, plastic bags, water storage drums, subterranean waters and refuse filled with rain (Christophers, 1960; Lee *et al.*, 1987; Gubler, 2002). However, *Ae. aegypti* is able to utilize natural available breeding sites as tree holes and leaf axils of bromeliads (Lee *et al.*, 1987). *Aedes aegypti* preferred breeding sites and its means of transmission studied in many areas, in USA and Puerto Rico discarded automotive tires were found to be an ideal sites (Tinker, 1964; Moore *et al.*, 1978; Chambers *et al.*, 1986) and large drums were their preferred sites in Colombia (Nelson *et al.*, 1984) overhead tanks and cement tanks in addition to tires in India (Sharma *et al.*, 2005).

*Aedes* introduction to new focus in a geographical area occurs via transportation of dormant viable eggs through transported and stored used tires and/or transfer of adult in different transportation vehicles (Reiter, 1993).

*Aedes* mosquito was involved in many recorded epidemics in Saudi Arabia of arboviruses (Godsey *et al.*, 2003; Rathor, 1996), Rift Valley Fever (Jupp *et al.*, 2002; Miller *et al.*, 2002; Moutailler *et al.*, 2008) and Dengue (Ghaznawi *et al.*, 1997; Fakeeh and Zaki, 2001).

*Aedes aegypti* was established as the primary indigenous vector of recent urban dengue virus outbreaks in Jeddah and Makkah, Saudi Arabia, nearby cities to Al-Madinah Al-Munawwarah. Dengue virus activity has never been reported in Al-Madinah. We succeeded to report *Aedes aegypti* through an entomological survey for 2 months (May-June 2008) in Al-Madinah which was an impetus to conduct an entomological survey for a year from July 2008 to detect *Aedes* prevalence and fully document their seasonal variations and populations diversity in Al-Madinah geographical region of the kingdom which is of importance to implement and designing effective vector control strategies.

## MATERIALS AND METHODS

### Study Area

An entomologic survey were carried out in the Al-Madinah Al-Munawwarah central region and surrounding province in housing areas as *Aedes* is known as a domestic mosquito. Al-Madinah Al-Munawwarah is located approximately 420 km North of Jeddah and Makkah. It is situated at 24°46'N, 39°61'E and 631 m above sea level. It is a semi-cultivated desert area.

### Mosquito Collection

Adult mosquitoes were collected twice weekly to include basement of 10 building under constructions surrounded by inhabited buildings and 10 inhabited buildings in and surrounding central area, also 10 housed farms around the central area of Al-Madinah Al-Munawwarah where 46 areas were surveyed once monthly. They were collected for a year, from July 2008-June 2009, using Black Hole UV trap produces CO<sub>2</sub> indoor and in yards and gardens close to the human dwellings and farms overnight and knockdown spray-sheet

procedure indoors at morning (Service, 1993). After collection, the captured insects were kept in a humid and cool environment and rapidly transported to the laboratory. In laboratory they were observed with a dissecting microscope to separate the *Aedes* from other insects and sorted by sex. Male *Aedes* were stored in 1.5 mL vials containing 95% ethanol, latter were mounted in Hoyer's medium for taxonomic identification. Females *Aedes* mosquitoes were examined for feeding (the presence or absence of blood in each female's midgut) and the status of any blood (digested or not). Also, they were examined for parity (as being gravid or not) by analyzing their ovarian development according to Christophers (1960). Then examined female were pooled according to date and site of collection and stored at -80°C.

#### ***Aedes* Mosquitoes' Identification**

*Aedes* mosquitoes were mounted in Hoyer's medium and taxonomically identified using several keys (Edwards, 1941; Mattingly and Knight, 1956; Hopkins, 1952; Jupp, 1996; Rueda, 2004).

#### **Statistical Analysis**

All the results were tabulated and presented by figures and histograms; descriptive statistics were performed using Statistical Package for the Social Sciences (SPSS for Windows Version 13, 2005).

## **RESULTS**

A total of 463 *Aedes* mosquitoes were identified, all of them were *Ae. aegypti*; 300 (64.8%) females and 163 (35.2%) males (Table 1). The mosquitoes were collected from inside homes and farms and in the area surrounding them. The distribution and seasonal variation of collected *Ae. aegypti* mosquitoes showed in Table 1 and Fig. 1.

Domiciliary distribution of *Ae. aegypti* collected in Al-Madinah Al-Munawwarah from July 2008 to June 2009 was represented in Table 1 and Fig. 2. Most of caught females were

**Table 1:** *Aedes aegypti* population collected in Al-Madinah Al-Munawwarah from July 2008 to June 2009

Month	Houses (building)						Farms					
	Indoor			Outdoor			Indoor			Outdoor		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
Jul 08	7	2	9	4	3	7	3	2	5	2	7	9
Aug 08	4	0	4	2	2	4	2	1	3	1	3	4
Sep 08	5	1	6	2	1	3	3	0	3	2	4	6
Oct 08	6	1	7	1	0	1	4	1	5	1	2	3
Nov 08	4	1	5	4	2	6	2	0	2	3	3	6
Dec 08	8	0	8	3	2	5	3	1	4	3	3	6
Jan 09	6	1	7	5	3	8	4	3	7	3	5	8
Feb 09	18	4	22	4	2	6	11	5	16	3	8	11
Mar 09	21	6	27	7	3	10	13	5	18	4	10	14
Apr 09	31	6	37	8	3	11	17	8	25	7	14	21
May 09	22	8	30	7	4	11	8	5	13	3	11	14
June 09	11	2	13	3	1	4	4	1	5	1	3	4
<b>Total</b>												
No.	143	32	175	50	26	76	74	32	106	33	73	106
%	30.9	6.9	37.8	10.8	5.6	16.4	16.0	6.9	22.9	7.1	15.8	22.9
Mean	11.92	2.67	14.58	4.17	2.17	6.33	6.17	2.67	8.83	2.75	6.08	8.83

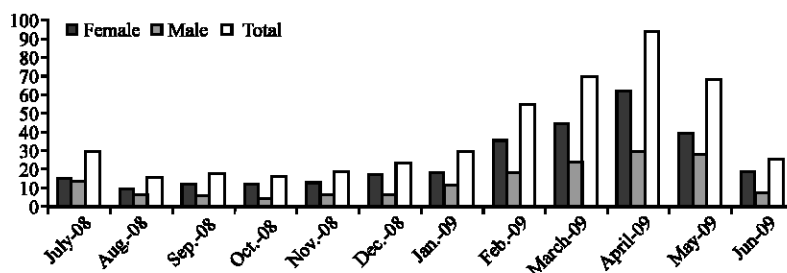


Fig. 1: Seasonal variation of *Ae. aegypti* population collected in Al-Madinah Al-Munawwarah from July 2008 to June 2009

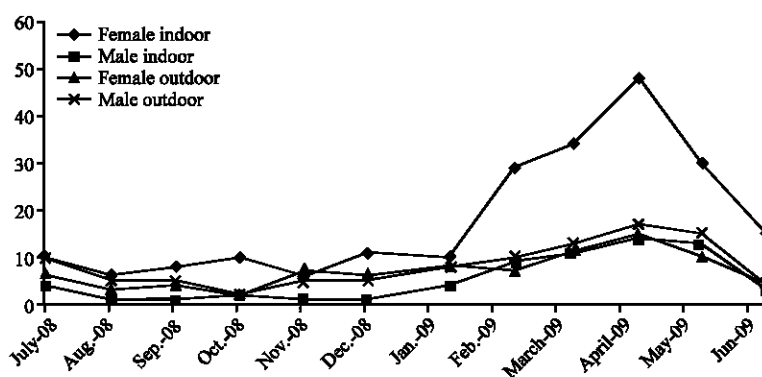


Fig. 2: Indoor and outdoor *Ae. aegypti* collected in Al-Madinah Al-Munawwarah from July 2008 to June 2009

Table 2: Results of *Ae. aegypti* female mosquitos' examination for feeding status and parity, collected in Al-Madinah Al-Munawwarah from July 2008 to June 2009

Month	No. of examined females	Feeding status		Parity	
		Non feed	Feed	Non-parous	Parous
Jul 08	16	9	7	5	4
Aug 08	9	5	4	5	0
Sep 08	12	7	5	7	0
Oct 08	12	8	4	6	2
Nov 08	13	10	3	7	3
Dec 08	17	10	7	7	3
Jan 09	18	11	7	8	3
Feb 09	36	21	15	15	6
Mar 09	45	28	17	18	10
Apr 09	63	42	21	30	12
May 09	40	26	14	18	8
June 09	19	12	7	8	4
Total	300	189	121	134	55

intradomiciliary 217/300 (72.33%), 134 from inside buildings and 74 from inside farms while males were dominant extardomiciliary 99/163 (60.74%), 26 and 73 from outside of buildings and farms, respectively (Table 1, Fig. 2).

Females were examined for feeding status and parity and their results were presented in Table 2. Most of examined females were not blood fed (63%), 70.9% of them were non-parous (Table 2).

## DISCUSSION

*Aedes aegypti* was the primary established indigenous domestic vector of recent outbreaks of urban dengue in Saudi Arabia (Ghaznawi *et al.*, 1997). To our knowledge, it was detected for the first time in Al-Madinah Al-Munawwarah, Western of Saudi Arabia by the authors at the beginning of 2008. Al-Madinah showed recent human-environmental changes in addition to continuity of dengue sporadic cases in nearby cities, Jeddah and Makkah (Fakeeh and Zaki, 2001, 2003; Ayyub *et al.*, 2006; Khan *et al.*, 2008) led us to conduct an entomological survey during which adult *Aedes* mosquitoes were collected from areas in Almadinah Al-Munawwarah region, throughout a period of a year from July 2008 to June 2009. Determination of adult mosquitoes population size of value to direct and guide control measures. The entomological survey is an important tool to get entomological data required for proper and effective designing of control programs and to create an early warning system. The mosquitoes were classified by sex, parity and feeding (for females). This study reports for the first time the prevalence and seasonality of *Aedes* in Al-Madinah Al-Munawwarah.

*Ae. aegypti* was the only identified *Aedes* mosquito species. It was detected year round with minimal seasonality; it peaked at April. Seasonal variation in population density and distribution is common for *Ae. aegypti* since, it is sensitive to changes in temperature and available moisture, it decrease in density in dry and cool seasons and they increase when temperatures increase and the wet season begins (Schultz, 1993).

Human-environmental changes are responsible for establishment and proliferation of *Ae. aegypti* population, this facilitates *Ae. aegypti* contact with humans. Al-Madinah showed recent human-environmental changes with growing in construction projects with the presence of many buildings under constructions, rapid urbanization, the presence of farms around Al-Madinah and different life style with wide use of air conditioners and evaporative coolers, which provide manmade breeding sites suitable for establishment and proliferation of *Aedes* mosquitoes. Also, the presence of few old buildings with two- to three-floor flats, housing four to six families which provide dark, cool, humid microclimatic sites ideal for *Aedes*. The growing urban population (both local and migration) and the increasing population mobility with rapid and development of transportation in Al-Madinah also are added risk factors that may contribute to further geographic expansion and density of *Ae. aegypti*.

The existence of this species throughout the year in Al-Madinah Al-Munawwarah is probably due to the arid climate and manmade breeding sites as the subterranean sites in building under-construction, watering practices and subsequent behavior by local residents, in addition farms in Al-Madinah Al-Munawwarah have to be watered more frequently to maintain vegetation, but this practice may serve to create and support sustained, suitable breeding sites for *Aedes*. These available *Aedes* breeding sites apparently not affected by rains and sustain year round existence of *Aedes* in Al-Madinah. Similar distribution was also reported by Russell *et al.* (1996) in semi-arid area of Australia. *Ae. aegypti* habitats vary almost as greatly as man's habitats, for their primary requirement is the presence of man. From the results of this comprehensive collection, in Al-Madinah *Ae aegypti* was anthropophilic and endophilic. It was evident that the mosquitoes were more abundant indoor followed by sheltered housing area (Table 1). *Aedes aegypti* was identified in all surveyed residential areas in Al-Madinah, its urban; peri-domestic and anthropophilic nature has also been shown in many studies (MacDonald, 1956; Surtees, 1969; Harrison *et al.*, 1972; Trpis and Hausermann, 1978; Jupp, 1996; Schultz, 1993).

It was also noted that the number of total positive buildings was more in February-May 2009 and peaked at April to decline in August-September 2008.

Although, climatic conditions and water availability may be the reason for this difference as Al-Madinah showed flooding event by rainfall days preceding *Aedes* surge in February-April, as *Aedes* eggs enter diapauses state during dry seasons, with lifetime ranging from weeks to few years until a flooding such as extreme tide or rainfall occurs which indicates the breeding habitats (Bicout *et al.*, 2002) this difference also may be due to the nature of *Aedes* breeding sites and habitats in Al-Madinah Al-Munawwarah and is more likely to be related to favorable cooler temperatures of these months. In addition these months showed and preceded by the growing intensive traffic between Jeddah and Makkah.

As expected, collected female mosquitoes outnumbered the males in the examined buildings because females are the blood-feeders of these insects. Anautogenous female *Aedes* mosquitoes imbibe vertebrate blood for oogenesis (Clements, 1992) except female *Ae. Aegypti*, it feed exclusively on human blood and very rarely on sugar (Harrington *et al.*, 2001). This explain more abundance of female mosquitoes indoors (Table 1). Regarding mosquito density in the examined sites, it was found that the highest was in February-May 2009 (Fig. 1). The feeding and gravidity of the collected female mosquitoes revealed a difference in the number of fed and non-fed collected mosquitoes (Table 2) the non-fed females were much higher in number in some months. This is unlikely to represent a clue to their feeding habits but is possibly a coincidence having to do with the fact that there is no way to control the number or ration of fed vs non-fed mosquitoes falling into the traps used to collect them. Regarding parity and fecundity, none of the collected females were parous in September and October 2008. This had also been preceded by a surge in parity in the previous months and followed by a decline in parity in the next months. This is likely to shed light on the mating season habits of *Aedes* mosquitoes in Almadinah region and can may be implemented to design control strategies.

It is believed that the arrival of adult *Aedes* mosquitoes to Al-Madinah has been favored by the growing intensive traffic between both Jeddah and Makkah especially there is a major motorway among them. It seems that the main mode of transmission of *Aedes* by transport of viable, dormant eggs through transported and stored used tires do not apply here but needs to be fully investigated.

In conclusion, the recent human-environmental changes in Al-Madinah Al-Munawwarah provided manmade breeding sites that facilitate *Ae. aegypti* introduction, maintenance and establishment with possibility of population proliferation. Moreover, rapid transport developments are risk factors augmented by tourism and trade links. The obtained results clearly determined *Ae. aegypti* distribution and seasonality in Al-Madinah Al-Munawwarah. The obtained few number of *Aedes* mosquitoes in this study, were due to the successful implementation of control programs by local health authority. These results necessitate further epidemiological surveillance and implicate regular strict monitoring of *Ae. aegypti* in Al-Madinah Al-Munawwarah, to overrule the possibility of *Ae. aegypti* establishment in Al-Madinah, with the potential risk of dengue transmission also, they are of importance to local health authority to successfully plan and implement their proper effective control programs.

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