International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Study of *Aedes* mosquito (Diptera: Culicidae) in Jeddah City, Western Kingdom of Saudi Arabia (2017-2018)

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International Journal of Science and Research Archive, 2025, 14(02), 1464-1471

Publication history: Received on 22 December 2024; revised on 02 February 2025; accepted on 05 February 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.14.2.0329

Abstract

Vector-borne diseases, particularly malaria and dengue fever, are responsible for over 700,000 deaths each year and represent more than 17% of all infectious diseases worldwide. This study aimed to study of *Aedes* mosquito in Jeddah City, KSA from November 2017 to October 2018. A cross-sectional study was conducted in randomly selected stations in urban localities of Jeddah City. Larvae and adults were collected using the recommended standard methods. The collected larvae and adults were taken to the laboratory for identification. Data was analyzed using SPSS version 24. From a total of 162062 breeding habitats a number of 12442 was found positive (7.7%). The breeding habitats air conditions tanks (a window air conditioner condensation) was represent most of the breeding habitats 19.9% followed underground water tanks 16.4% and agriculture basins 12.6%. House index was found high during November 2017 (17.8%) and January 2018 (18.6%) and lowest during May 2018 (5.1%). However container index was found high during October 2018 (16.5%), February 2018 (15.9%) and September 2018 (15.6%) and found low during August 2018 (6.2%). There was significance difference between house index and breatu index during dry and wet season, $p<0.05$. House index and breatu index were significantly found high during wet season compared to dry season. All the collected adult *Aedes* mosquito was identified as *Ae. aegypti*. In conclusion *Ae. aegypti* was prevalent in Jeddah City throughout the year. Urgent vector control activities is highly recommended.

Keywords: Aede; Mosquito; Culicidae; Jeddah; Kingdom Saudi Arabia

1. Introduction

Aedes aegypti is the proven as efficient vector of dreadful viral diseases, such as dengue and hemorrhagic fever. According to a new estimate. 3.6 billion (55% of the world's populations) are at risk of dengue in 124 endemic countries with an estimated 21,000 deaths /yr. In Africa, viral hemorrhagic fevers (VHFs) include Lassa fever, Rift Valley fever, Marburg and Ebola, and yellow fever (Eritja et al., 2017; Espinal et al., 2019).

Dengue is a viral infection caused by four types of viruses (DENV-1, DENV-2, DENV-3, DENV-4) belonging to the Flaviviridae family. The viruses are transmitted through the bite of infected *Aedes aegypti* and *Ae. albopictus* female mosquitoes that feed both indoors and outdoors during the daytime (from dawn to dusk). These mosquitoes thrive in areas with standing water, including puddles, water tanks, containers and old tires. Lack of reliable sanitation and regular garbage collection also contribute to the spread of the mosquitoes (Liu et al., 2020; Shastri and Taneja, 2021).

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Several mosquito species are of medical importance, but *Aedes* Meigen (Diptera: Culicidae) species are becoming the most important from a medical point of view all over the world. *Aedes* species (especially Ae. *aegypti* and Ae. albopictus) are vectors of arboviruses that infect various vertebrates, including humans. The most common arboviruses spread by *Aedes* species and infecting humans are the dengue fever virus, yellow fever virus, and chikungunya virus. It is the most serious mosquito-borne viral disease worldwide. DF is an acute febrile illness caused by *Ae. aegypti* and *Ae. albopictus*, which are endemic in certain cities of Saudi Arabia, such as Jeddah and Makkah (Alikhan et al., 2014). DF is an acute febrile illness caused by *Ae. aegypti* and *Ae. albopictus*, which are endemic in certain cities of Saudi Arabia, such as Jeddah and Makkah (Alhaeli et al., 2016).

Yellow fever is an acute viral hemorrhagic disease transmitted by infected mosquitoes. Up to 50% of severely affected persons without treatment will die from yellow fever. There are an estimated 200 000 cases of yellow fever, causing 30 000 deaths, worldwide each year. The virus is endemic in tropical areas of Africa and Latin America, with a combined population of over 900 million people (WHO, 2014).

The objective of this study was to study of *Aedes* mosquitoes in Jeddah town KSA from November 2017 to October 2018, through identifying the species of *Aedes* and determining all the habitats and breeding sites of *Aedes* mosquito.

2. Material and methods

2.1. Study design

A cross-sectional study was conducted in randomly selected stations in urban localities.

2.2. Study area

The city of Jeddah is located on the west coast of the Kingdom (latitude 21.29 N and longitude of 39.7 E), in the middle of the eastern shore of the Red Sea. To the East are the plains of Tihama, i.e. the low elevations of the Hijaz region, to the west along the beach there are parallel chains of coral reefs. Population: 3.9 million, It is the main Saudi seaport on the Red Sea. Architecture: a mixture of ancient mud houses .The urban boundary of Jeddah is 1765 km^2, the total area of the municipality is 5460 km^2, with growth rate of 3.5% per annum (14% of KSA population. It is the second largest city in Saudi Arabia. The kingdom population: 25.37 million. The weather is hot and humid during most of the year, but one gets used to temperatures of between 30- 40 °C.

2.3. Selection of sentential sites

In Jeddah each strata is divided to one sentinel site according to strata of the Dengue fever programs. However the number of sentinel sites were 7 sites/month, for 12 months.

2.4. Collection of larvae

A light torch, white enamel pans, and fine mesh sieve were used. The larvae was collected from the suspected water containers (larvae or pupae) inside the house. Water in positive containers was filtered using the sieve by pouring on clean water to the white pans.

2.5. Collection of adults

Black light mosquito trap (a small U-shaped light bar with a wavelength of 365 nm and with the sucking fan in the bottom of the trap) was used to capture adults. Each light trap was suspended 1.5 m above the ground. Traps were positioned linearly at a single location with a minimum distance of 20 m between trap sites.

2.6. Identification of the trapped mosquitoes

Identification was done on the basis of adult female morphological characters with the help of different standard taxonomic keys and catalogues (Rueda 2004; Azzam 2006).

2.7. Data Analysis

The obtained data were analyzed using SPSS version 24. The appropriate statistical tools were used. *P-value* considered significant at less than 0.05 level.

3. Results

3.1. The breeding sites

Table (1) and figure (1) indicates that from a total of 162062 breeding habitats about (7.7%) of the sites were positive. The breeding habitats air conditions tanks was represent most of the breeding habitats 19.9% followed by underground water tanks 16.4% and agriculture basins 12.6%.

Table 1 *Aedes aegypti* larval breeding sites in Jeddah City

Type of habitats	Total	+ve site	%
Air conditions tanks (window air conditioner condensation)	1891	377	19.9
Underground water storage tanks	29023	4773	16.4
Agriculture basins	1722	217	12.6
Bird drinking	3132	300	9.6
Barrels	7377	634	8.6
Drinking water coolers	18894	712	3.8
Surface water pools	4592	448	9.8
Mosques	22731	1558	6.9
Brick manufactures	15945	730	4.6
New underground constructing	10485	681	6.5
Cars repair shops	4242	259	6.1
Schools	14063	387	2.8
Clinic centers	9650	329	3.4
Laundry shops	4003	320	8.0
Workers houses	14312	717	5.0
Total	162062	12442	7.7

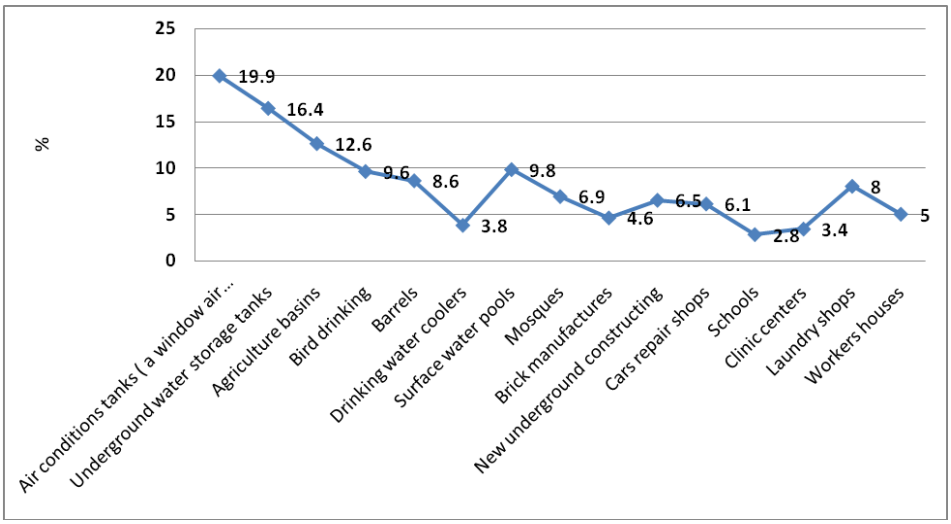

Figure 1 Proportion of each type of breeding habitats in Jeddah City

3.2. House index and container index

Table (2) and figure (2) shows that house index was found high during November 2017 (17.8%) and January 2018 (18.6%) and lowest during May 2018 (5.1%). However container index was found high during October 2018 (16.5%), February 2018 (15.9%) and September 2018 (15.6%) and found low during August 2018 (6.2%).

Table (3) illustrates that there was significance difference between house index and breatu index during dry and wet season, $p<0.05$. House index and breatu index were significantly found high during wet season compared to dry season.

Table 2 Number of houses inspected, houses infested, number of containers inspected, infested containers, house index (HI) and Container index (CI) by months in Jeddah City

Months	No. of houses inspected	No. of houses infested	% HI	No. of containers inspected	No. of infested containers	% CI
November 2017	2220	395	17.8	3055	441	14.4
December 2017	2305	295	12.8	3399	490	14.4
January 2018	2024	376	18.6	3812	433	11.4
February 2018	2620	356	13.6	2972	472	15.9
March 2018	2620	345	13.2	3849	463	12.0
April 2018	2413	187	7.7	2951	295	10.0
May 2018	1970	112	5.7	3075	261	8.5
June 2018	1898	175	9.2	2907	299	10.3
July 2018	2225	84	3.8	2697	256	9.5
August 2018	1899	96	5.1	2615	163	6.2
September 2018	2320	188	8.1	2495	390	15.6
October 2018	2412	139	5.8	2763	455	16.5
Total	26926	2748	10.2	36590	4418	12.1

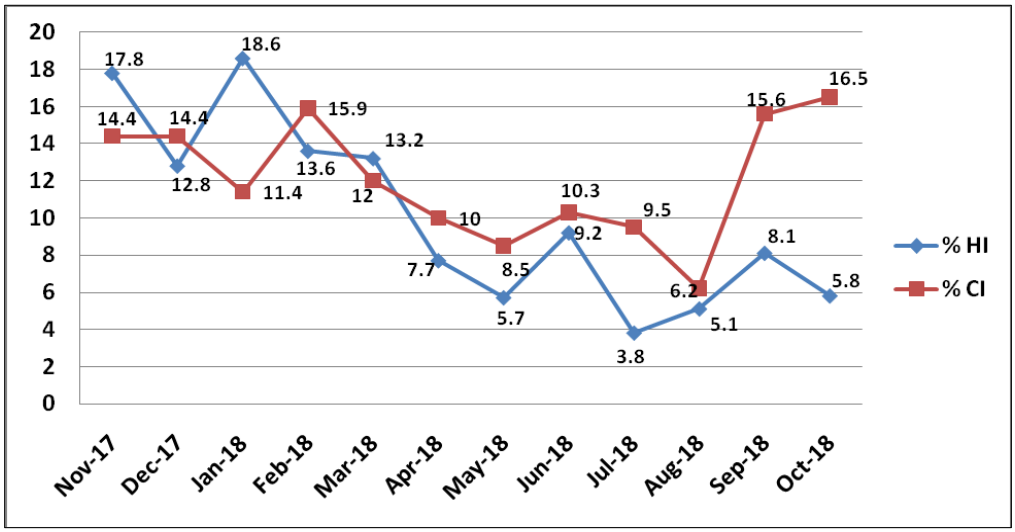

Figure 2 Proportion of house index and containers index by months in Jeddah City

Table 3 Mean (mean+SE) of house index, Breatu index and containers index in dry and wet season in Jeddah City

Season	% HI	% BI	% CI
Dry	6.5±.7	5.01±.6	10.9±1.4
Wet	15.2±1.2	10.5±.8	13.6±.8
Total	10.1±1.4	7.3±.9	12.0±.9
P-value	.000	.000	.176

3.3. No. of trapped mosquitoes

Table 4 and figure 3 shows that a total of 1993 adult *Aedes* mosquito were caught by CDC traps 1213 (60.9%) and by black hole light trap 780 (39.1%). The most adult of *Aedes* mosquito caught by CDC traps was reported in May 2018 (12.2%) followed by November 2017 (11.5%). While the most adult *Aedes* mosquito collected by black hole light trap was recorded in September 2018 (12.6%) and February 2018 (11.5%).

Table 4 Total *Aedes* adult caught by CDC and black hole light trap by months in Jeddah City

Months	Total adult *Aedes* caught			
	CDC Trap		Black hole light trap	
	No.	%	No.	%
November 2017	139	11.5	27	3.5
December 2017	83	6.8	55	7.1
January 2018	57	4.7	44	5.6
February 2018	87	7.2	92	11.8
March 2018	134	11.0	48	6.2
April 2018	95	7.8	65	8.3
May 2018	148	12.2	71	9.1
June 2018	136	11.2	66	8.5
July 2018	87	7.2	55	7.1
August 2018	83	6.8	82	10.5
September 2018	88	7.3	98	12.6
October 2018	76	6.3	77	9.9
Total	1213	100.0	780	100.0

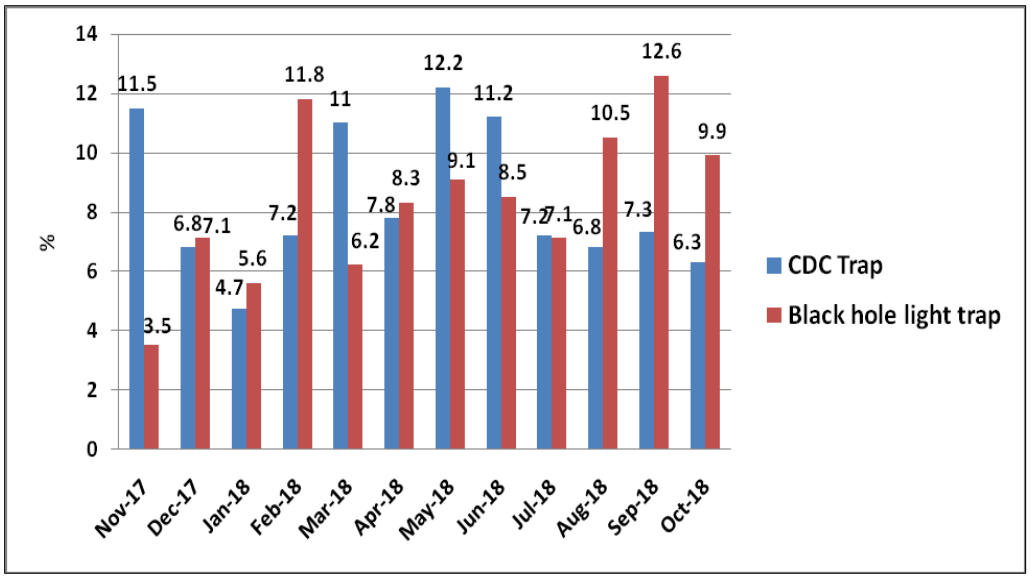

Figure 3 Percent of adult *Aedes* caught by CDC and black hole trap by months in Jeddah City

3.4. Identification of the trapped mosquitoes

Table 5 explains that all the collected adult *Aedes* mosquito was identified as *Ae. aegypti*. Table 6 shows that there was no significance difference between method of adult *Aedes* collection either CDC traps or black hole light trap, $P>0.05$.

Table 5 Mosquito species identified in Jeddah City

Total adult *Aedes* identified	***Ae. Aegypti***		***Other species***	
	No.	**%**	**No.**	**%**
1993	1993	100.0	0	0.0

Table 6 Mean (mean ± SE) of adult *Aedes* caught by CDC trap and black hole light trap during dry and wet season in Jeddah City

Season	**CDC Trap**	**Black hole light trap**
Dry	101.8±10.7	73.4±5.2
Wet	100.0±15.8	53.2±10.7
Total	101.1±8.6	65.0±5.9
P-value	.921	.093

4. Discussion

Vector-borne diseases, particularly malaria and dengue fever, are responsible for over 700,000 deaths each year and represent more than 17% of all infectious diseases worldwide (WHO, 2012). Their huge impact makes them the most significant contemporary public health risk. Dengue fever (DF) is an incredibly notorious example of vector-borne disease. DF is the most common vector-borne disease worldwide and, thus, also the most important (Heymann, 2008).

The present study aimed to study of *Aedes* mosquitoes in Jeddah town KSA from November 2017 to October 2018 with specific objectives of identify the species of *Aedes* in the city from November 2017 to October 2018, determine all the habitats and breeding sites of *Aedes* mosquitoes and identify the effect of season variation in indices and adult population collection. In terms of breeding habitats the study showed that the breeding habitats air conditions water

tanks was represent most of the breeding habitats 19.9% followed by underground water tanks 16.4% and agriculture basins 12.6%.

These findings in line with Aziz *et al*. (2012) who suggested that, vector control programs should focus on these breeding sites using an integrated approach that targets larval mosquitoes. Such an approach would require environmental management, law enforcement, regulation, public awareness campaigns, health education, personal protection, and dry days.

This study showed that house index was found high during November 2017 (17.8%) and January 2018 (18.6%) and lowest during May 2018 (5.1%). However container index was found high during October 2018 (16.5%), February 2018 (15.9%) and September 2018 (15.6%) and found low during August 2018 (6.2%). Also there was significance difference between house index and breatu index during dry and wet season, $p<0.05$. House index and breatu index were significantly found high during wet season compared to dry season. While there was no significance difference between method of adult *Aedes* collection either CDC traps or BHL traps, $P>0.05$. This situation alarm of arbovirus outbreak in future according to the Pan American Health Organization and the WHO, an area is at a high risk of arbovirus transmission when these indices are above a threshold of 5% for the HI and BI and 3% for the CI.

The effect of seasonal variations on the abundance and distribution of *Aedes* mosquitoes has been reported by other authors (Vezzani *et al*., 2004; Wongkoon *et al*., 2013).

The indices reported in our study is lower than that obtained in northern Ghana also showed higher house indices ranging from 55.9% to 88.3% (Appawu *et al.*, 2010). The findings from another study in the rural Ifakara district of south-eastern Tanzania revealed relatively lower larvae indices than those found in this study. In terms of breatu index, the findings are not agreed with the results reported from a study in northern Ghana, where breatu indices of 72.4 to 180.9 were reported during a dry season (Kahamba *et al*., 2020).

To some extent similar study conducted in Eastern Sudan showed that he highest *Aedes aegypti* container index was recorded in Kassala State, at Aroma locality, (27.3%) and followed by Kassala locality (21%) and Shmal Aldalta locality (15.4%). The breatu index in this area varied from (39.6%) in the Kassala locality to (22.2%) in Shmal Aldalta locality. However, the *Aedes aegypti* house index was found to be (19%) in Kassala locality. The highest level of breeding was detected in pots (zeer) (99.7%) followed by neglected ground well in Kassala mountains (Toteel hill) (0.3%) (Abdalmagid and shaaeldinne, 2008).

Furthermore the study showed that all the collected adult *Aedes* mosquito was identified as *Ae. aegypti*. Also the species was found throughout all the year but the density was significantly increased in wet season (rainy season). These findings support that *Ae. aegypti* mosquitoes are capable of continual adaptation to environmental change. Eggs of *Ae. aegypti* can withstand desiccation and survive without water for several months on the inner walls of containers. Vector control programs have not adequately addressed these challenges. These programs struggle to control or eliminate *Ae. aegypti* mosquitoes because of their complex behavior and continuous adaptation to the environment (Amarasinghe *et al*., 2011). In addition the seasonal increase in population necessitates an increase in water storage and an increase in potential larval habitats

5. Conclusion

It can be concluded that *Aedes* mosquito was prevalent in Jeddah City throughout the year. There were different types of breeding habitats mostly air conditions water tanks (window-air conditioner condensation) and underground storage tanks and agriculture basins. However wet season was significantly affect prevalence of *Aedes* mosquitoes. The high indices (HI, BI, CI) is alarm of outbreak of arbo-viral in the near future unless vector control activities start early. The identification of the trapped mosquitoes shows the dominance of *Aedes aegypti.*

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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