International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2020; 7(4): 49-53

www.dipterajournal.com
Received: 24-05-2020
Accepted: 26-06-2020

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# A preliminary study on the infestation indices of dengue vector, *Aedes aegypti* (Diptera: Culicidae) in Taif, Saudi Arabia

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**Abstract**
Surveys were carried out (August to November; 2018 and 2019) in 12 residential districts of Taif city to examine the overall entomological indices (House Index, HI; Container Index, CI and Breteau Index, BI) for *Aedes aegypti* larvae. A total of 682 houses were inspected of which 193 were positive and of 1139 containers, 370 were found positive for larval breeding. The calculated indices were 28.3% HI, 32.5% CI and 54.3% BI with significantly higher values in 2019 period (42.2% HI, 42.7% CI and 77.0% BI, $P<0.001$) than in 2018. Significantly higher indices were observed for the northern part (37.7% HI, 39.9% CI and 66.7% BI, $P<0.05$) than those for the other parts of the city. The reported dengue cases during the study periods coincided with the difference in larval abundance in the different parts of Taif. The abundance of breeding containers resulting from vast and extensive constructions (that require much of water storage) is the factor responsible for the abundance of larvae (high indices) than temperature and humidity. The obtained results may be of importance for determining the risk of dengue transmission and planning of an efficient control program. However, further intensive studies are required to examine the status of the vector/ dengue fever in Taif city/governorate.

**Keywords:** *Aedes aegypti*, entomological indices, dengue fever, Taif, Saudi Arabia

## 1. Introduction
Mosquito fauna of the Kingdom of Saudi Arabia (KSA) was investigated by several workers [1] of which several species are important as vectors of diseases mainly Dengue fever [2, 3, 4], filariasis [5, 6, 7], malaria [4, 8], Rift Valley Fever [9, 10, 11], Sindbis virus [12] and West Nile Virus [13].

*Aedes* (*Stegomyia*) *aegypti* (L) "*Stegomyia (St.) aegypti"* is the primary established indigenous domestic vector of Dengue fever virus (DFV) in KSA, which was isolated for the first time from an adult in Jeddah in 1994 [14, 15]. Of the previous surveys, 31 reports identified *Ae. aegypti* [7] in different parts of the kingdom mostly in western part. In only two occasions entomological surveys were conducted in Taif, of which one [1] was positive and the other [16] was negative in identifying *Ae. aegypti*.

The DFV activity has been reported in the western areas of the Saudi Arabia; Jeddah, Makkah, and Almadinah [17, 18]. In general between 1993 and 2008, three major Dengue epidemics were reported in Saudi Arabia, resulting in more than 2,500 cases and again in 2015, 6,000 cases were reported, leading to the death of six patients [19]. In Jeddah, from February 1994 via December 2002 the total proved cases were 319 [2, 14]. Moreover, the situation in Jeddah is alarming as number of dengue fever cases is increasing rapidly. The year 2006 was the worst year for Jeddah as 1300 cases of dengue fever were recorded but due to extensive efforts of Jeddah Municipality the number came down to 342 in 2007 [19]. In Taif, 20 Dengue cases were recorded from Nov 2016 to Oct 2019 by Taif Health Affairs Directorate, Ministry of Health (THAD; MOH, Unpubl.).

*Aedes aegypti* is closely associated with human environments in endemic areas, where indoor and outdoor artificial containers like clay-pots, tires, barrels, flower-vase, cement basins and Jerry cans make adequate habitats for larval development [20]. The indoor breeding premises are believed to be the main cause behind the recurrent and escalating dengue epidemics [21].

Entomologic surveillance of *Ae. aegypti* has been based on different larval indices [22] namely the House Index (HI), Container Index (CI) and Breteau Index (BI) [23]. The indoor breeding premises are the major risk for dengue infection in Jeddah and House Index is a major parameter for detecting dengue outbreaks [21]. In only two occasions the entomological indices were determined for *Ae. aegypti* in Jeddah [21, 24] but these indices were not demined through the Taif survey by Hassan *et al.* [1]. For this, the present study examines for the first time the entomological indices of *Ae. aegypti* in Taif city. This is important for determining the risk of dengue transmission and planning of an efficient control program.

## 2. Materials and methods

### 2.1 Study sites

The present study was carried out in some districts of Taif city during August to November (2018 and 2019). Taif (Figure 1) is a city of Mecca Region (21°16′30.34″N 40°24′22.16″E). It is located in the western side of the Kingdom at an elevation of 1,879 m on the slopes of Al-Sarawat mountains with a population of 1,281,613 people (2010-2011) and an area of 321 km$^2$. It has varied terrain, mountains, valleys and plains. Besides Taif has a large number of dams where water is stored to irrigate farms, lands and crops. The city is the center of an agricultural area known for its grapes, figs, roses and honey. Taif has a hot desert climate, with hot summers and mild winters. The surveyed districts (Table 1) were selected according to notification of suspected Dengue cases by THAD, MOH and were visited twice a month during the study periods.

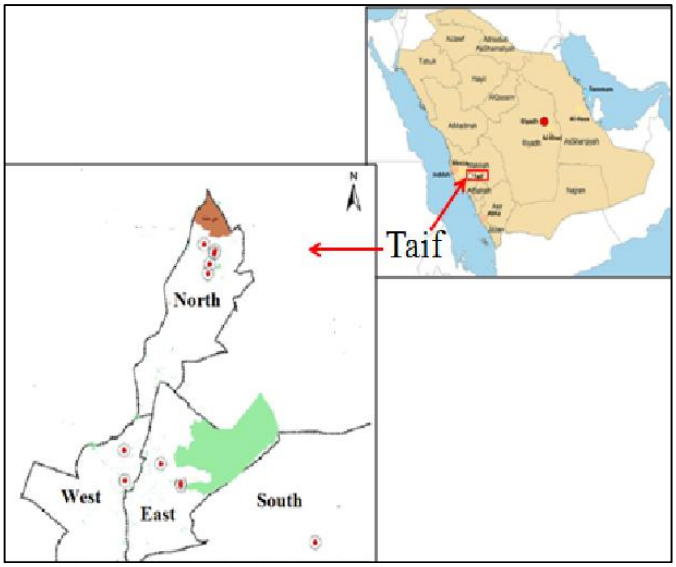


**Fig 1:** Location of Taif city in the western side of Saudi Arabia

**Table 1:** Coordinates of the surveyed districts of Taif city

| Districts | | Latitude | Longitude |
|---|---|---|---|
| North | Sultanah | 21.44511 | 40.48210 |
| | Al Hawiyah | 21.43057 | 40.48712 |
| | Little Torrent | 21.50207 | 40.48017 |
| | Al Faisaliah | 21.42349 | 40.48541 |
| | Al Pakistaniah | 21.44041 | 40.49190 |
| East + West | Industrial zone | 21.26831 | 40.45975 |
| | Al Salama | 21.27245 | 40.40968 |
| | Masara | 21.29481 | 40.40921 |
| | Al Nasem | 21.27042 | 40.45970 |
| | Al Baiyaa | 21.28462 | 40.44165 |
| South | Al Ser | 21.22553 | 40.57934 |
| | Laiya | 21.22182 | 40.53837 |

### 2.3 Larval collections

Water containers inside and outside houses (mainly the uncovered underground reservoirs, concrete surface water basins used for under construction buildings, discarded car tires, barrels and different cans) were examined for *Ae aegypti* larvae using a plastic dipper, 125 mm in diameter with a 90 cm aluminum telescoping handle. Collected larvae were placed in labeled plastic bags (Nasco whirl pack 4002 filline USA) and transported to the laboratory in a picnic ice box containing cold water to prevent overheating. At the laboratory, 3rd and 4th larval instars were killed with hot water and preserved in labeled specimen tubes containing 70% ethyl alcohol to be ready for identification. Larvae were identified according to the morphological keys [16, 25, 26].

### 2.4 Calculation of entomological indices

The entomological indices of larvae: House Index (HI: % age of houses infested with larvae), Container Index (CI: % age of water-holding containers infested with larvae) and Breateau Index (BI: No of positive containers per 100 houses inspected) [27] were calculated as follow:

$$\text{HI} = \frac{\text{No. of positive houses}}{\text{No. of houses inspected}} \text{ X100}$$

$$\text{CI} = \frac{\text{No. of positive containers}}{\text{No. of containers inspected}} \text{ X100}$$

$$\text{BI} = \frac{\text{No. of positive containers}}{\text{No. of houses inspected}} \text{ X100}$$

### 2.5 Data analysis

Means ± SE of the entomological indices for compiled data of the two survey periods (2018 and 2019) and of the different areas (North, East + West and South) were calculated and compared for significant difference by the one way-ANOVA.

If F showed significant inequality of the means, they were further exposed to pairwise comparisons based on Tukey's honestly significant difference (HSD) test. The PAST (PAleontological Statistics, Version 2.08) computerized software [28] was used for statistical analysis.

## 3. Results

Surveys of *Ae. aegypti* larvae were carried out in 12 residential districts of Taif city during the period from August to November (2018 and 2019). A total of 682 houses were inspected of which 193 were positive and of 1139 containers, 370 were found positive for larval breeding (Table 2). The calculated indices were 28.3%, 32.5 and 54.3 for HI, CI and BI, respectively.

**Table 2:** Positive houses and water containers for *Aedes aegypti* larvae in Taif city (August- November 2018 & 2019)

| District | Houses | | Containers | |
|---|---|---|---|---|
| | No | +Ve | No | +Ve |
| Sultanah | 65 | 28 | 105 | 49 |
| Al Hawiyah | 66 | 31 | 92 | 46 |
| Little Torrent | 47 | 18 | 66 | 23 |
| Al Faisaliah | 60 | 13 | 108 | 40 |
| Al Pakistaniah | 44 | 17 | 103 | 32 |
| Industrial zone | 58 | 11 | 84 | 23 |
| Al Salama | 60 | 18 | 84 | 31 |
| Masara | 59 | 6 | 86 | 13 |
| Al Nasem | 42 | 8 | 69 | 16 |
| Al Baiyaa | 96 | 35 | 192 | 80 |
| Al Ser | 46 | 8 | 83 | 17 |
| Laiya | 39 | 0 | 67 | 0 |
| Total | 682 | 193 | 1139 | 370 |

Comparison of the calculated indices (Mean±SE ) of the two year periods (Figure 2) indicated that significantly higher values ($P$<0.001) were obtained in 2019 (42.2±6.9, 42.7±6.1 and 77.0±10.8% for HI, CI and BI, respectively) than in 2018 (7.7±2.8, 11.6±4.2 and 17.4±6.4% for HI, CI and BI, respectively).

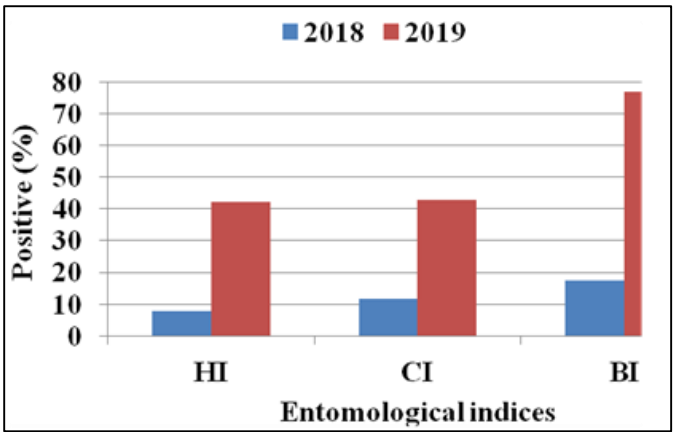


**Fig 2:** Overall indices for *Ae. aegypti* larvae in Taif city (August – November, 2018 and 2019). House Index (HI), Container Index (CI) and Breteau index (BI) calculated as positive houses or containers out of the total inspected ones

Compiling the results of the two years for the different areas and calculating the mean indices/district (Table 3) indicated that significantly higher indices were observed for the northern part than those for the other parts ($P$<0.05).

**Table 3:** Overall entomological indices (Mean±SE) calculated for *Ae. aegypti* in Taif city during August to November (2018 + 2019)

| Area | House Index | Container Index | Breteau Index |
|---|---|---|---|
| North | 37.7±4.3 a | 39.9±3.6 a | 66.7±4.7 a |
| East + West | 23.0±4.6 b | 28.9±4.8 b | 47.0±10.2 b |
| South | 8.7±8.7 c | 10.3±10.3 c | 18.5±18.5 c |
| $F_{2,9}$ / P | 6.3 / 0.02 | 6.2 / 0.02 | 4.8 / 0.04 |

In each column, means with different letters are significantly different,
Turkey's HSD test, $P$<0.05.

## 4. Discussion

The mosquito *Ae. aegypti* is the primary established indigenous domestic vector of DFV in KSA which has been reported in the western areas of the Saudi Arabia; Jeddah, Makkah, and Almadinah [17, 18] since 1994 and still circulating till now. Between 1993 and 2008, three major epidemics were reported, resulting in more than 2,500 cases. Again in 2015, 6,000 cases of dengue fever were reported leading to the death of six patients [19].

Generally, entomologic surveillance of *Ae. Aegypti* has been based on different larval indices [22] namely the House Index (HI), Container Index (CI) and Breteau Index (BI) [23]. In only two occasions the entomological indices were determined for *Ae. aegypti* in Jeddah [21, 24] but such indices were not previously demined through the previous Taif survey [1]. For this, the present study examines the entomological indices of such mosquito vector in Taif city. Such indices (mainly HI) are important for determining the risk of dengue transmission and planning of an efficient control program. The House Index was reported to be a major parameter for detecting dengue outbreaks so that control measures should aim at household [21].

The results of entomological survey in 12 residential districts of Taif city during the period from August to November (2018 and 20199) indicated that the overall indices of the two year periods altogether were 28.3% HI, 32.5 CI and 54.3 BI with significantly higher indices in 2019 (42.2% HI, 42.7% CI and 77.0% BI, $P$<0.001) than in 2018 (7.7% HI, 11.6% CI and 17.4% BI). Similarly, in Jeddah [21], the House Index and Breteau Index were significantly different ($P$<0.01) between 2012 (3.4 HI and 4.6 BI) and 2013 (5.8 HI and 9.6 BI). As nearly similar temperatures were reported during the two periods of the study (ca.28 ºC temp. and 29% RH), such higher indices in 2019 than in 2018 may be attributed to the abundance of breeding containers which is a result of human activities such as extensive constructions (that require much of water storage) than to environmental factors including temperature and humidity. Similarly, it was reported.[29] that the spread of *Ae. aegypti* in Jeddah is related more too human behavior than to climate.

Compiling the results of the two year periods for the different areas (north, east+west and south) indicated difference in larval indices of such areas. The highest indices were observed for the northern part (37.7% HI, 39.9% CI and 66.7% BI, $P$<0.05) and the lowest indices were in the south. The higher indices in the northern part may be due to the vast and extensive constructions in this area than in the other old parts of Taif. Al-Ghamdi *et al.* [24] conducted house-to-house surveys of larval population of *Ae. aegypti* in 6 sites of Jeddah governorate and found some significant differences among the investigated areas with House indices were: 4 - 8.7%

($P$<0.05) as compared with the highest ratio of standard WHO (5-10%).

Of the 20 dengue cases reported in Taif (THAD; MOH, Unpubl.), 14 were reported during Oct - Nov 2018 (13) and 1 in Oct 2019. Of these 11 in north,2 in east and 1 in south which coincided with the significantly higher incidences in northern part.

## 6. Conclusion

The calculated indices whether for the two study periods or the different areas were higher than the highest ratio of standard WHO (5-10%). The abundance of breeding containers which is a result of human activities is the factor responsible for the abundance of larvae than temperature and humidity. The reported dengue cases during the study periods coincided with the difference larval abundance in the different parts of Taif. The obtained results may be of importance for determining the risk of dengue transmission and planning of an efficient control program. However, further intensive studies are required to examine the actual status of the vector/ dengue fever in Taif governorate including Taif city.

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