Research Article

Surveillance of Dengue Fever Vector *Aedes aegypti* in Different Areas in Jeddah City Saudi Arabia

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Abstract | The seasonal abundance of adult mosquitoes in Jeddah city was investigated throughout the year, 2010. Light traps (black holes) and manual methods were used for collecting adults and immature stages in five residential areas in Jeddah. A total of 796 adults of *Aedes aegypti* mosquitoes were collected. Out of these, 373 males (46.8 %) and, 423 females (53.2%). Out of 950 collected immature stages, 83.41% larvae and 16.6% were pupae. The obtained statistical analysis showed that the availability of the adult and juvenile stages of *A. aegypti* occurred throughout the year in different densities depending on the climatic conditions and the effectiveness of the breeding sites. The density of adult were 2.61 (Ghuleel), 2.55 (Al-Jameiah), 2.25 (Al-Balad), 2.47 (Al-Safa) and 1.86 (Al-Nazlah Al -Yamaneyyah). Whereas the density of immature stages were 5.03 (Ghuleel), 4.01 (Al-Balad), 2.48 (Al-Jameiah), 2.38 (Al-Safa) and 1.91 (Al-Nazlah Al-Yamaneyyah) at the level of significance ($P< 0.05$). The density of immature stages of *A. aegypti* in March, April, May, and December has shown a significant increase. Two peaks for the seasonal abundance of the adults were showed in April, January, October and December, because of the optimum climatic condations (temperature and humidity) in those months.

Keywords | *Aedes aegypti*, Immature stages, Surveillance, Dengue fever, Jeddah city

Received | October 17, 2021; **Accepted** | December 08, 2021; **Published** | January 10, 2022
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Citation | Al-Azab AM, Zaituon AA, Al-Ghamdi KM, Al-Galil FMA (2022). Surveillance of dengue fever vector *Aedes aegypti* in different areas in Jeddah city Saudi Arabia. Adv. Anim. Vet. Sci. 10(2): 348-353.
DOI | http://dx.doi.org/10.17582/journal.aavs/2022/10.2.348.353
ISSN (Online) | 2307-8316

INTRODUCTION

Mosquitoes are considered important arboviruses for humans owing to their biting and blood feeding habits. They play an important role as vectors of diseases such as dengue fever (WHO, 1996). Dengue fever is now endemic in 129 countries worldwide and hundred countries in Mediterranean region, South America and South East Asia with about 40.000 death yearly while the yellow faver cause 30,000 deaths annually (WHO, 2000, 2003; Whitehorn and Farrar, 2010, 2014). Potential of of *Aedes aegypti* population as well as adult and immature stages survival are playing a key role in dengue virus transmission. Outbreaks of DF/DHF cause high morbidity and mortality in a short period of time, and can create a panic among the people anticipateing urgent action from the government. In Saudi Arabia and Arabian Peninsula many researchers studied the distribution of mosquito (Diptera: Culicidae) adults as well as larvae and recorded 46 species and subspecies (Mattingly and Knight, 1956). In the 1990s, outbreaks have been reported in West Asia, with a major epidemic occurring in Jeddah, Saudi Arabia (Fakeeh and Zaki, 2001; Gubler, 1997). It is an essential to know about the abundance and species composition of mosquitoes and evaluate an influential mosquito in the particular area to perform control program (Reinert, 1989).

Aedes aegypti, is highly adapted species to the urban environment distributed widly in wormer regions espacialy in tropical and subtropical zones as well as beyond the Arctic Circle. Because of its habitat, It is plays an important role in the arboviruses transmission, mainly the dengue and urban yellow fever (Gubler, 2002). The procedures of adult vector sampling can assist a specific studies and provide a valuable data such as transmission risk, transmission dynamics, seasonal population trends and evaluation of interventions of adult control management. The effective investigation of vector species, and their pathogens, is fundamental to the evaluation of disease risk and time-critical implementation of appropriate transmission prevention measures and mosquito control.

The current study aimed to investigate and monitoring mosquito mapping potential and population as well as breeding sites by using black hole traps for adults of *A. aegypti*.

MATERIALS AND METHODS

Adult mosquito collection and identification

Adults of *A. aegypti* were collected using Black Hole traps from five different locations in Jeddah City.

Study sites

This study was conducted in Jeddah city located at 21° 32′ 36′ N and 39° 10′ 22′ E latitude and longitude at western region of Saudi Arabia from five locations. These residental locations were (AL-Nazlaah, Al-Yamaneyyah, AL-Jameiah, AL-Safa, Ghuleel, and AL-Balad) (Table 1) selected according the population density reports of mosquitoes at these areas (Figure 1 and 2).

Mosquito collection

The survival of adult and immature stages of *Ae aegypti* was estimated in Jeddah City in which sporadic outbreaks of *A. aegypti*-borne dengue viruses occurred in recent years. *A. aegypti* abundance was conducted by: (a) monitoring of adult abundance and (b) Monitoring of breeding sites for immature stages.

Monitoring of adult abundance

Adults of mosquito were collected using light traps (Black Hole). One trap was set in each location every week from sunset until the following morning during the period of study. Captured adults were transferred to the laboratory to record their population dynamic and carried identification procedures.

Monitoring of breeding sites

The monitoring of breeding sites randomly selected containers or breeding sites was weekly inspected. All immature stages were collected with a pipette into plastic containers and transferred to the laboratory. Then they were killed using killing vials containing 70% alcohol and preserved for identification.

Identification of adult mosquito

Collected adults mosquitoes were killed by keeping them in the freezer at -20°C for 30 minutes, then left in the lab conditions and room temperature for 30 minutes. All collected Adults and immature stages were counted and identified according to identification keys (Mattingly and Knight 1956; Rueda, 2004) and followed the Walter Read Biosystematics Unit (WRBU, 2010).

Table 1: Coordinates of study locations in Jeddah governorate.

Location	Coordinate	
	N	E
Al-Nazlah Al-Yamaneyyah	21.4728754	39.20689261
Ghuleel	21.45213269	39.20259096
Al-Jameiah	21.47087433	39.25174507
Al-Safa	21.58961988	39.2111804
Al-Balad	21.48253853	39.187563

Statistical analysis

In this study,a completely randomized design (CRD) in factorial experiment was conducted. The collected data were analyzed statistically by (ANOVA) analysis of variance tes using SAS software program SAS Institute (2006) version 9.3 and the means were compared by LSD at P≤ 0.05.

RESULTS AND DISCUSSION

The order of the population density of *A. aegypti* in studied areas was categorized reported as Ghuleel, Al-Jameiah, Al-Balad, Al-Safa and Al-Nazlah Al-Yamaneyyah takes into consideration both adults and immature stages, respectively. Ghuleel was the highest 2.6 and 5.0 while Al-Nazlah Al-Yamaneyyah was the lowest in 1.8 and 1.9 for adult and immature stages of *A. aegypti* abundance respectively as shown in Table 2 and 3.

Table 2: Abundance of *A. aegypti* stages adults and immature stages in five residential districts (Jeddah, KSA, 2010).

Abundance means of *A. aegypti* stages		
Location	Adult	Immature stages
Al-Jameah	2.555 a *	2.483 c*
Guleel	2.611 a	5.033 a
Al-Balad	2.250 a b	4.016 b
Al-Safa	2.472 b	2.383 c
Al-Nuzlaah Al-Yamaniah	1.861 b	1.916 c

*Means followed by the same letter (s) in the same column are not significant different according to LSD at (0.05).

Figure 1: Study location in western of Saudi Arabia.

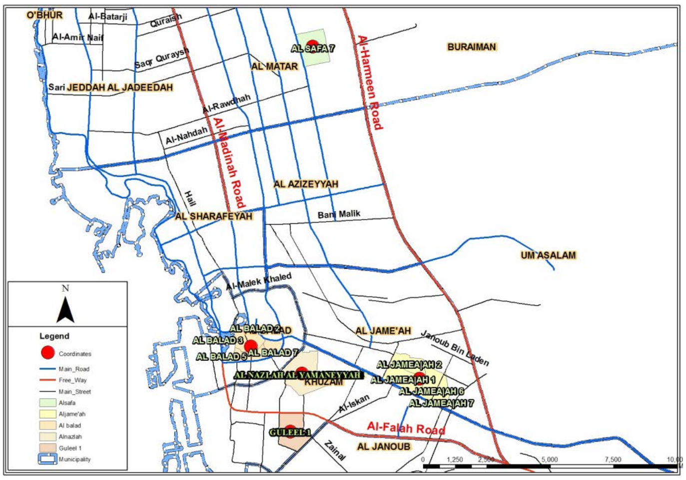

Figure 2: *Aedes aegypti* collection sites in five residential locations in Jeddah governorate.

Table 3: Abundance (Mean ± SE) of *A. aegypti* adults and immature stages in the study locations in (Jeddah, KSA 2010).

	Mean ± SE	
Location	**Adult**	**Immature stages**
Al-Jameah	2.555± 0.2656	2.483 ±0.376
Guleel	2.611± 0.2332	5.033 ± 0.5042
Al-Balad	2.250 ±0.2713	4.016 ± 0.3761
Al-Safa	2.472 ± 0.4903	2.383 ±0.2912
Al-Nuzlaah Al-Yamaniah	1.861 ±0.1330	1.916 ±0.1451

Data in Table 4 and Figure 3 showed that there was overall increase in *A. aegypti* population density during two periods throughout the year during April and October which showed significantly increasing during April compared with October due to the optimum climatic factors including suitable temperature, relative humidity and rainfall which make breeding mosquito sites ideal habitats for multiplication and wide spread distribution.

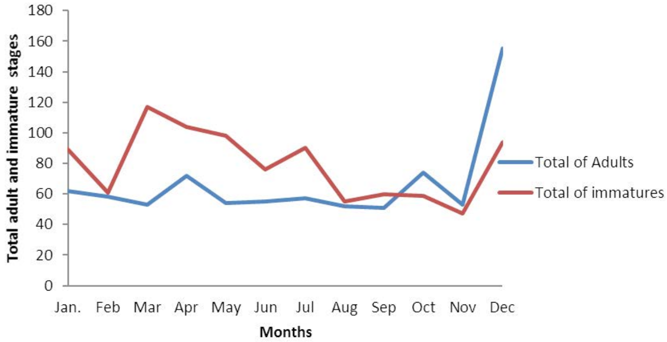

Figure 3: Population denisity of *A. aegypti* in all locations during year of 2010 (Jeddah -KSA).

Table 4: Monthly abundance of *A. aegypti* adults and immature stages in (Jeddah, KSA 2010).

Means of *A. aegypti* in studied area		
Months	**Adult**	**Immature stages**
Jan	2.201 b*	3.560 abcd*
Feb	1.801 b	2.440ced
Mar	1.866 b	4.680 a
Apr	2.733 b	4.160ab
May	1.721 b	3.920 ab
June	1.944 b	3.040 cbed
July	1.933 b	3.601 cab
Aug	1.743 b	2.210 e
Sep	1.733 b	2.401 ced
Oct	2.666 b	2.360 de
Nov	1.800 b	1.880 e
Dec	6.066 a	3.760ab

*Means followed by the same letter (s) in the same column are not significant different according to LSD at (0.05).

The means of monthly abundance of *A. aegypti* adults and immature stages in studied areas throughout the year showed an overall increase of adult stages in April , October, January and December with values 2.73, 2.66, 2.20 and 6.06 while the values of immature stages were 4.68 , 4.16 , 3.90, 3.70 during March, April, May and December, respecively (Table 5).

The distribution of dengue fever vector *A. aegypti* has changed dramatically over the last six years. It has expanded its range into new regions outside its normal habitat hence this relative abundance due to most probably to environmental changes resulting from human activities. Data plotted in in Figure 4 Indicated that the effect of cilmatic factors on abundance of *A. aegypti* adult and immature stages and shown the relationship between climatic factors and *A. aegypti* biology ant also shown its interference in the efficiency of transmitting dengue viruses during wormer condation.

Table 5: Monthly (Mean±SE) dynamics population of *A. aegypti* throughout the year 2010.

	Mean ± SE	
Months	**Adult**	**Immature stages**
Jan	2.201 ± 0.2000	3.560± 0.55100
Feb	1.801 ±0.2225	2.440 ± 0.33705
Mar	1.866 ± 0.1919	4.680 ± 0.96733
Apr	2.733 ± 0.2839	4.160 ± 0.4989
May	1.721 ± 0.2281	3.920 ± 0.5413
June	1.944 ± 0.2839	3.040 ±0.6620
July	1.933 ± 0.2481	3.601 ± 0.7852
Aug	1.743 ± 0.2062	2.210 ± 0.2000
Sep	1.733 ± 0.2481	2.401± 0.2380
Oct	2.666 ± 0.4327	2.360 ± 0.2508
Nov	1.800 ± 0.2794	1.880 ± 0.1942
Dec	6.066 ± 0.9282	3.760 ± 0.6410

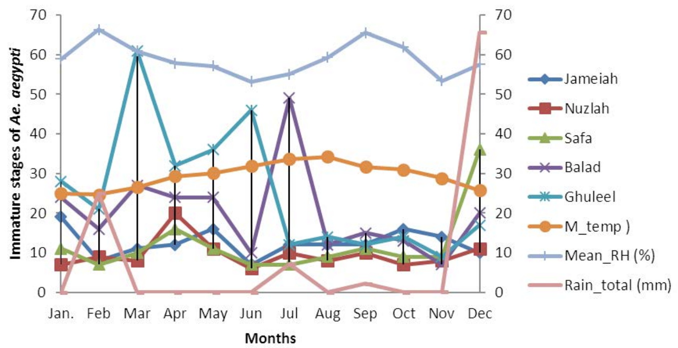

Figure 4: The relationship between abundance of immature stages *of A. aegypti* and climatic factors (Jeddah, KSA 2010).

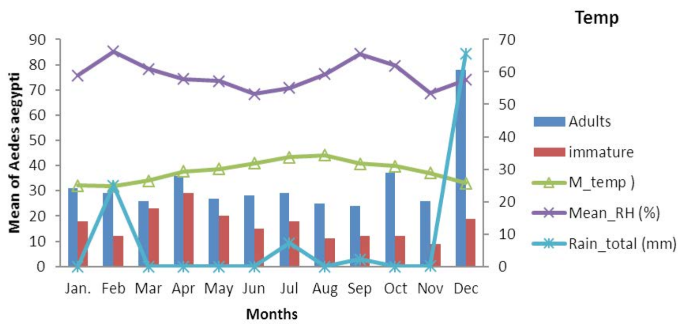

Figure 5: The relationship between abundance of adult , immature stages *of A. aegypti* and climatic factors (Jeddah, KSA 2010).

The incidence of DF/DHF in Jeddah governorate has become a challenge for evolving appropriate vector control strategies to prevent possible outbreaks. Most dengue fever cases are recorded in 2010 during the period from 2006-20012 as shown in Figure 6. Also the data reveal that the number of cases increases from March to June confirming the active transmission period during the year Figure 7.

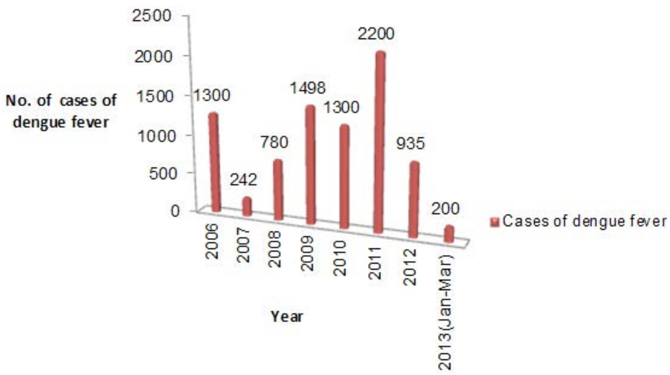

Figure 6: Dengue fever cases in Jeddah governorate during the years (2006-2012 Municipality of Jeddah district).

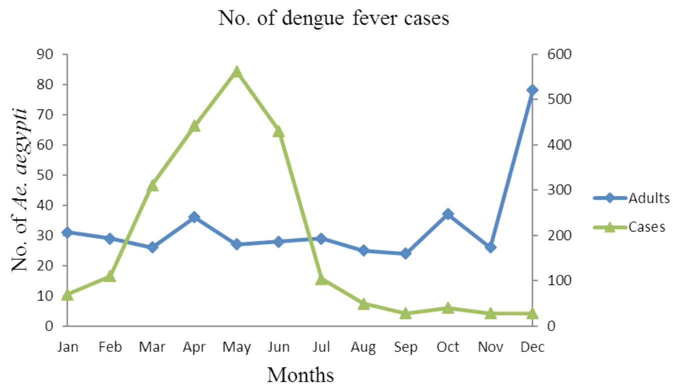

Figure 7: The relationship between abundance of *A. aegypti* and incidence of dengue cases in Jeddah during 2010.

In spite of the ongoing mosquito control efforts in Jeddah which have probably aided in the reduction of *A. aegypti* densities and dengue cases, it was common to find isolated breeding sites and habitats of *A. aegypti*. It is possible that vector populations may be reduced in focal sites on households and containers, but also targeting new non-household settings might help to further reduce larvae in non-disposable containers. This will probably require changes in human behavior and the combined efforts of the public and the vector control personnel.

This study provides an indication that the presence of *A. aegypti* throughout the year with the grave increase in the density during months of March, April, May, and December. The source of breeding in settlement sites of dengue fever vectors must be reduced to prevent the weekly/monthly dengue cases. The water must be prevented from stagnating in the pools. Thus, not providing a larval habitat for *A. aegypti*. Integrated vector management (IVM) such as source reduction, surveillance studies, insecticide applications, biological control, education and public awareness as well as personal protection should be implemented in Jeddah in order to monitor and control the populations of dengue vectors.

A. aegypti population density during two periods of the year April and October showed significantly increasing during April compared with October due to the optimum climatic factors which was suitable for the mosquito. These results are in agreement with (Al-Qahtani, 2009) who revealed that the highest population dynamics of *A. aegypti* was during May however declining gradually until October. Our results are also inagreement with (El-Khereji et al., 2007) who reported that two peaks for the seasonal activity of the adults in December-January and during April-May, respectively. The other study conducted in Al-Hsaa district in Eastern Saudi Arabia revealed that mosquitoes in Al-Ahsaa are prevalent in both winter and spring seasons, however rarely encountered during summer and are found in moderate levels during the autumn months (Ahmed et al., 2011). Also the estimation of *A. aegypti* distribution and density were affected by the life-limiting factors such as mean temperatures , monthly average rainfall, humidity, season, habitat and dispersal (Lee, 1991; Hales et al., 2002; Vythilingam et al., 2005; Khormi et al ., 2011).

This data is consistent with (Rosa-Freitas et al., 2006; Wu et al., 2007) who reported that climate is a very important component of the spatial and temporal distribution of dengue fever vectors. Other studies showed that the relationship between climatic factors and *A. aegypti* biology is well established for its interference in the efficiency of the vector in transmitting dengue viruses (Scott et al., 2000; Tun-Lin et al., 2000; Hales et al., 2002) The study conducted by (Chakravarti and Kumaria, 2005) suggested that analysis of three climatic factors such as rainfall, temperature and relative humidity were very important as these factors could affect the mosquito breeding activities

The warmer temperature may allow the vectors to survive and reach maturity much faster than at lower temperature (Lindsay and Mackenzie, 1997). It may reduce the size of mosquito larvae resulting in smaller adults that have a high metabolism rate and need to lay eggs more often (Brunkard et al., 2008).

The number of dengue cases start to rise about one month after rain, this observation is consistent with (Wellmer, 1983) This strongly suggests that appropriate vector control measures needed to be implemented during this critical period of time to reduce the population density of dengue fever cases, whereas during December there was a high abundance of vectors but no apparent DF cases was reported. This emphasizes the need for continuous monitoring of dengue virus infections in the mosquitoes vectors in the infested areas. This strongly suggests that appropriate vector control measures need to be implemented during this period to reduce the case incidence of dengue fever. Whereas in December there was, high abundance of vectors but no apparent DF cases was reported. This emphasizes the need for continuous monitoring of dengue virus infections in vector mosquitoes in infested areas (Tuladhar et al., 2019).

CONCLUSIONS AND RECOMMENDATIONS

The density of *A. aegypti* adult were 2.61 (Ghuleel), 2.55(Al-Jameiah), 2.25 (Al-Balad), 2.47 (Al-Safa) and 1.86 (Al-Nazlah Al-Yamaneyyah, Whereas the density of immature stages were 5.03 (Ghuleel), 4.01 (Al-Balad), 2.48 (Al-Jameiah), 2.38 (Al-Safa) and 1.91 (Al-Nazlah Al–Yamaneyyah), throughout the year respectively. The immature stages of *A. aegypti* were significant increase in the density in March, April, May, and December. Two peaks for the seasonal abundance of the adults were showed in April, January and October, December.

ACKNOWLEDGMENTS

We are deeply thankful to king Abdulaziz city for science and technology (KACST) for financial support under grant no. (A-S-10-0013). We gratefully acknowledge the Municipality of Jeddah for helping us during this study and special thanks to the Ministry of Health for providing data of dengue infested areas in Jeddah.

NOVELTY STATEMENT

This work is the first work that deals with the Surveillance of mature and immature stages of Dengue fever vector Aedes aegypti and links it with the climatic factors in the Jeddah City of Saudi Arabia.

AUTHOR'S CONTRIBUTION

AMA designed and performed the experiments and analyzed the results and wrote the draft paper, AAZ and KMA supervised the study and assisted in paper writing. FMA discussed the results and contributed to the final manuscript arrangement. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Ahmed AM, Shaalan EA, Aboul-Soud MA, Al-Khedhairy AA (2011). Mosquito vectors survey in Al-Ahsaa district, eastern region, Kingdom of Saudi Arabia. J. Insect Sci., 11: 1-11. https://doi.org/10.1673/031.011.17601

Al-Qahtani H (2009). Determination of population density of mosquitoes in the field using the clark traps with evalution of some insectices against *Aedes aegypti* in Jeddah Governorate. Ph D. thesis Biological Science Department, Faculty of Science, King Abdulaziz University.

Brunkard J, Cifuentes E, Rothenberg S (2008). Assessing the role of temperature, precipitation and ENSO in dengue re-emergence on the Texas-Mexico border region. Salud Pública de México, 50: 227-234. https://doi.org/10.1590/S0036-36342008000300006

Chakravarti A, Kumaria R (2005). Eco-epidemiological analysis of dengue infection during an outbreak of dengue fever, India. Virol. J., 2(32): 1-7. https://doi.org/10.1186/1743-422X-2-32

El-Khereji MA, Alahmed AM, Kheir SM (2007). Survey and seasonal activity of adult mosquitoes (Diptera: Culicidae) in Riyadh City, Saudi Arabia. Res. Bull. 152 Food Sci. Agric. Res. Center, King Saud Univ., pp. 5-17.

Fakeeh M, Zaki A (2001). Virologic and serologic surveillance for dengue fever in Jeddah, Saudi Arabia, 1994-1999. Am. J. Trop. Med. Hyg., 65: 764-767. https://doi.org/10.4269/ajtmh.2001.65.764

Gubler DJ (1997). Dengue and dengue hemorrhagic fever: its history and resurgence as a global public health problem. In: Gubler DJ. Kuno G. Editors. Dengue and dengue hemorrhagic fever. London: CAB International, pp. 1-22. https://doi.org/10.1016/S1045-1870(97)80003-9

Gubler, D (2002). The global emergence/resurgence of arboviral diseases as public health problems. Arch. Med. Res., 33: 330-342. https://doi.org/10.1016/S0188-4409(02)00378-8

Hales S, Wet N, Maindonald J, Woodward A (2002). Potential effect of population and climate changes on global distribution of dengue fever: An empirical model. Lancet, 360: 830-834. https://doi.org/10.1016/S0140-6736(02)09964-6

Khormi H, Kumar L, Elzahrany R (2011). Describing and analysing the association between meteorological variables and adult *Aedes aegypti* mosquitoes. J. Food Agric. Environ., 9(3-4): 954-959.

Lee HL (1991). A nationwide resurvey of the factors effecting the breeding of *Aedes aegypti* (L.) and *Aedes albopictus* Skuse (Diptera: Culicidae) in urban towns of Peninsular Malaysia 1988-1989. Trop. Biomed., 8: 151-160.

Lindsay M, Mackenzie J (1997). Vector-borne viral diseases and climate change in the Australian region: major concerns and the public health response, in climate changes and human health in the Asia-Pacific region P. Curson, C. Guest, E. Jackson, Eds., Aus. Med. Assoc. Greenpeace Inter., Canberra, pp. 47–62.

Mattingly P, Knight K (1956). The mosquito of Arabia. I. Bull. Brit. Mus. (Nat. Hist.) Entomol., 4(3): 89–141.

Reinert W (1989). The New Jersey Light Trap: An old standard for most mosquito control programs. Proceedings of the seventy sixth annual meeting of the New Jersey. Mosq. Contr. Assoc. Inc., pp. 17-25.

Reiter P (2001). Climate change and mosquito-borne disease. Environ. Health Persp., 109(suppl.1): 141-152. https://doi.org/10.1289/ehp.01109s1141

Rosa-Freitas MG, Schreiber KV, Tsouris P, Weimann ET, Luitgards-Moura JF (2006). Associations between dengue and combinations of weather factors in a city in the Brazilian Amazon. Revista Panamericana de Salud Pública. 20:256-67. https://www.scielosp.org/pdf/rpsp/2006.v20n4/256-267/en

Rueda L (2004). Pictorial keys for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission, Zootax, 589: 1-60. https://doi.org/10.11646/zootaxa.589.1.1

SAS Institute (2006). SAS users guide: Statistics: SAS Institute Inc., Cary NC.

Scott T, Amerasinghe P, Morrison A, Lorenz L, Clark G, Strickman D, Kittayapon P, Edman J (2000). Longitudinal studies of *Aedes aegypti* (Diptera: Culicidae) in Thailand and Puerto Rico: Blood feeding frequency. J. Med. Entomol., 37: 89-101. https://doi.org/10.1603/0022-2585-37.1.89

Tuladhar R, Singh A, Banjara MR, Gautam I, Dhimal M, Varma A, Choudhary DK (2019). Effect of meteorological factors on the seasonal prevalence of dengue vectors in upland hilly and lowland Terai regions of Nepal. Parasit. Vectors, 12(1): 1-15. https://doi.org/10.1186/s13071-019-3304-3

Tun-Lin W, Burkot T, Key B (2000). Effects of temperature and larval diet on development rates and survival of the dengue vector *Aedes aegypti* in north Queensland, Australia. Med. Vet. Entomol., 14: 31-37. https://doi.org/10.1046/j.1365-2915.2000.00207.x

Vythilingam I, Tan C, Nazni W (2005). Transmission potential of Wuchereria bancrofti by Culex quinquefasciatus in urban areas of Malaysia. Trop. Biomed., 22: 83-85.

Walter Read Biosystematics Unit (2010). Systematic catalog of culicidae. Online at http://www.mosquitocatalog.org.

Wellmer H (1983). The Dengue Haemorrhagic Fever Situation in Thailand Until 1970. InDengue Haemorrhagic Fever in Thailand (pp. 16-19). Springer, Berlin, Heidelberg.

Whitehorn J, Farrar J (2010). Dengue. Br. Med. Bull., 95: 161–173. https://doi.org/10.1093/bmb/ldq019

Whitehorn J, Farrar J (2014). editors. Dengue: Transmission, Diagnosis & Surveillance. Future Medicine Limited. https://doi.org/10.2217/ebo.13.743

WHO (1996). Climate change and human health, WHO Geneva.

WHO (2000). Dengue/dengue haemorrhagic fever. Weekly Epidemiol. Re., 75: 193-196.

WHO (2003). Guidelines for surveillance and mosquito control. Sec. ed. WHO Regional Office Edu. in action series, pp. 8-12.

WHO (2006). Guidelines for Surveillance and Mosquito Control. Sec. ed. WHO Regional Office Edu. in action series, pp. 29.

WHO (2020). World Health Organization. Mosquito-borne diseases.

Wu PC, Guo HR, Lung SC, Lin CY, Su HJ (2007). Weather as an effective predictor for occurrence of dengue fever in Taiwan. Acta tropica. 103(1):50-7. https://doi.org/10.1016/j.actatropica.2007.05.014