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Dengue Vector (*Aedes aegypti*) mosquito Invasion in Blue Nile State, Sudan, 2023

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ABSTRACT

Background: In urban and rural disparities in water storage practices and water source supply may affect mosquito immature abundance and, potentially, arbo-viral risk.

Objectives: This study aimed to identify the presence or absence of dengue vector *Aedes aegypti* and its invasion and indices in relation to dengue fever in Blue Nile State

Materials and methods: This cross-sectional entomological study was carried out in Blue Nile State , Sudan between September and October 2023. The mosquito immature stage including larvae and pupal stage of the genus *Aedes* were collected from the surveyed positive containers by sweep nets. In addition, the total number of larvae counted, and approximately 10% stored for species identification. The collected larvae and pupae were kept in plastic vials with 70% ethanol. Then taxonomic identification of mosquitoes was carried out in the entomology laboratory of the Blue Nile State by using appropriate taxonomic keys. Data was analyzed using

Microsoft Excel sheet.

Results: From a total of 50 houses in Surveyed areas of Blue Nile a number of 47 houses were found positive (94%) with a total of 215 different types of water containers inspected with 202 positive water containers that represent 94%. During the survey a number of 1300 pupae stage were collected. The *Aedes* entomological indices were found very high that reflects the invasion of the surveyed areas with *Aedes aegypti*. The House index (HI) was found 94% which ranged between 60-100% in the study areas. While the container index was found 94% with range between 78.6-100%. However the Breatu index (BI) was found to be 49.3% with range from 22.4-82.6%. The pupal per residence in the surveyed areas was 3.2 with range of 1.6-3.6. From 215 water containers inspected; a number of 67 (31.2%) were zeer, 46 (21.4%) were barrels; 16 (7.4%) were water condition and 74 (34.4%) were tires. The most containers inspected harboring *Aedes aegypti* mosquito were tires (34.4%) followed by zeer (31.2%).

Conclusion: Dengue vector (Aedes aegypti) is prevalent in Blue Nile State with high indices. Therefore there is a need to improve *Aedes* mosquito control practices in the State to reduce the risk of DENV transmission.

Keywords: *Dengue vector,Aedes aegypti, Blue Nile state, Sudan, 2023*

INTRODUCTION:

Entomological surveillance is used to determine changes in the geographical distribution and density of the vector, evaluate control programmes, obtain relative measurements of the vector population over time and facilitate appropriate and timely decisions regarding interventions. It may also serve to identify areas of high-density infestation or periods of population increase. (1)

Dengue is a mosquito-borne viral disease of global health concern. The disease has spread throughout the tropical and sub-tropical regions over the past 60 years and currently affects over half of the world's population (2). The disease is caused by dengue virus (DENV), an RNA virus with four distinct serotypes, DENV1–4, each capable of causing disease, ranging from mild fever to severe disease (3). The spread of DENV infection is driven by increased international travel, climate change effect associated with high humidity and temperature, and poor urban environmental conditions that favour mosquito survival, breeding, and abundance (4).

Dengue virus is transmitted between humans through a bite of an infected *Aedes* mosquito. The main vectors that are geographically widespread include *Ae. aegypti* and *Ae. albopictus* (3). *Ae. aegypti* is an extensive domestic day-biting species that prefer to feed on humans. It breeds in flower vases, uncovered barrels, buckets, discarded cans, roof gutters and discarded tires (5, 6) while *Ae. albopictus,* preferentially rests outdoors (7) and alternatively feeds on humans and animals, though it has been reported to exhibit strong anthropophagic behaviour in some countries (5). In Sudan mainly in Easternn and Western states, *Ae. aegypti* is the main vector of Dengue (9), no report on presence of *Ae. albopictus*.

The *Aedes* mosquito is responsible for the transmission of many arthropod-borne viruses (arboviruses), including dengue virus, yellow fever virus, Zika virus, and chikungunya virus (18). These arboviruses pose increasing global public health concerns because of their rapid geographical spread and increasing disease burden. In particular, dengue is the most important arboviral disease, and is widely distributed in the tropical and sub-tropical regions of the world (18). Infected female *Aedes* mosquitoes, mainly *Aedes* aegypti (Linnaeus) and also *Ae. albopictus* (Skuse), are the main vectors of several globally important arboviruses (3). Ae. aegypti (Linnaeus) is currently distributed in urban areas and usually breeds in indoor and outdoor settings in a wide variety of natural and artificial waterholding containers such as plastic tanks, leaves, water storage jars, cement tanks, flower vases, curing tanks, glasses, rubber tires, and plastic bottles. Breeding habitats in urban areas arise mostly from neglected areas of construction sites and stagnant water that can create favorable conditions for mosquitoes to breed (4). The purpose of this study is to identify the presence or absence of dengue vector *Aedes aegypti* and its invasion and indices in relation to dengue fever in Blue Nile State.

MATERIALS AND METHODS:

Study design:

This cross-sectional entomological study was carried out in Blue Nile State, Sudan between September and October 2023.

Study area:

Blue Nile State lied in southern part of the country bordering from southeast Ethiopia, southwest of South Sudan and north is Sinner state. With an area of 38,000 km square and 1,250.00 populations. Blue Nile River is crossing the state from south to north fed by numbers of streams and tributes. This gives unique feature for agricultural and live stocks herding activities. Rainy season starts early in June and ends in late October. Elroseres High Dam famous hydro-electric project that supplies country with electricity and irrigation water sources, particularly Aljazeera agriculture scheme and it is rich of mechanized agriculture in Al Tadamon locality. BNS is served by number of (160) health facilities (HFs). The population at Blue Nile State depends on different water sources. Water from network, which covers approximately (25%) of the population; The other sources are out network e.g., Hand pumps, water yards, dug wells (open/closed), river, seasonal streams, open sources (shallow wells, hafeers).

Mosquito Surveillance:

The mosquito immature stage including larvae and pupal stage of the genus *Aedes* were collected from the surveyed positive containers by sweep nets. In addition, the total number of larvae counted, and approximately 10% stored for species identification. The collected larvae and pupae were kept in plastic vials with 70% ethanol. Then taxonomic identification of mosquitoes was carried out in the entomology laboratory of the Blue Nile State by using appropriate taxonomic keys (5).

Data Collection:

Water containers in the selected 10 sites were inspected visually, and each was considered positive if either larvae or pupae were present. Data on the total number of containers present in each inspected household and the number of positive containers in each household were collected in addition to residents.

Data Analysis:

Data was analyzed using Microsoft excel sheet. Descriptive analyses i.e. frequency, percentage were used to analyze the data. *Aedes* abundance and indices were calculated.

RESULTS:

Table1 and figure 2 shows that from a total of 50 houses in Surveyed areas of Blue Nile a number of 47 houses were found positive (94%) with a total of 215 different types of water containers inspected with 202 positive water containers that represent 94%. During the survey a number of 1300 pupae stage were collected. The *Aedes* entomological indices were found very high that reflects the invasion of the surveyed areas with *Aedes aegypti*. The House index (HI) was found 94% which ranged between 60-100% in the study areas. While the container index was found 94% with range between 78.6-100%. However the Breatu index (BI) was found to be 49.3% with range from 22.4-82.6%. The pupal per residence in the surveyed areas was 3.2 with range of 1.6-3.6.

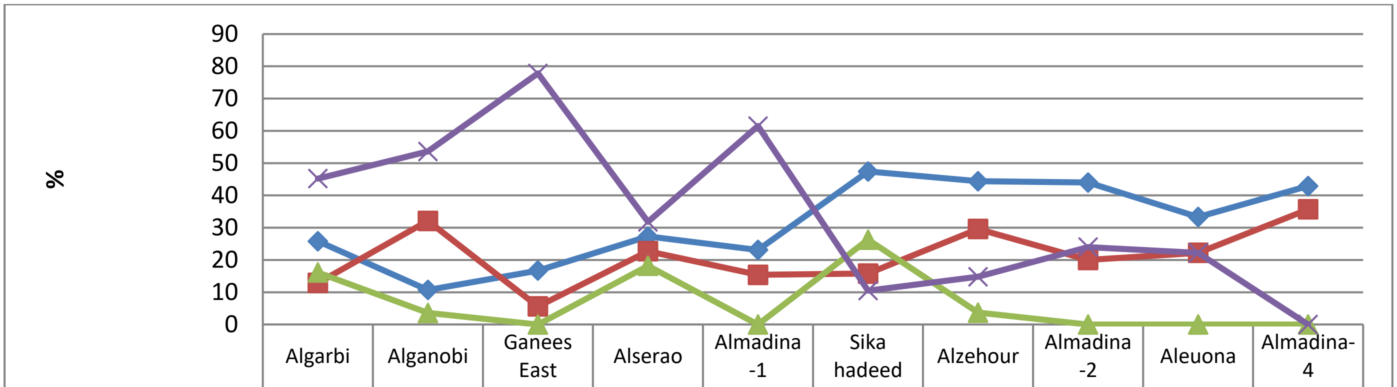
Table 2 and figure 1 shows that from 215 water containers inspected; a number of 67 (31.2%) were zeer, 46 (21.4%) were barrels; 16 (7.4%) were water condition and 74 (34.4%) were tires. The most containers inspected harboring *Aedes aegypti* mosquito were tires (34.4%) followed by zeer (31.2%).

Table 1: *Aedes aegypti* larvae survey and indices in different areas in Blue Nile State 2023

Area	No. of houses inspected	No. positive houses	Total residence	No. of water containers inspected	No. of positive containers	No. of Pupae	*Aedes aegypti* indices			
							HI	CI	BI	Pupae per residence
Algarbi	5	5	43	31	31	156	100	100.0	72.1	3.6
Alganobi	5	4	35	28	27	112	80	96.4	77.1	3.2
Ganees East	5	5	39	18	18	73	100	100.0	46.2	1.9
Alserao	5	5	28	22	22	187	100	100.0	78.6	6.7
Almadina -1	5	3	60	13	13	96	60	100.0	21.7	1.6
Sika hadeed	5	5	23	19	19	169	100	100.0	82.6	7.3
Alzehour	5	5	47	27	25	187	100	92.6	53.2	4.0
Almadina -2	5	5	53	25	22	160	100	88.0	41.5	3.0
Aleuona	5	5	33	18	14	82	100	77.8	42.4	2.5
Almadina-4	5	5	49	14	11	78	100	78.6	22.4	1.6
Total	**50**	**47**	**410**	**215**	**202**	**1300**	**94**	**94.0**	**49.3**	**3.2**

Table 2: *Aedes aegypti* larvae survey in different types of water containers indifferent surveyed areas in Blue Nile State 2023

Area	No. of water containers inspected	Type of water container							
		Zeer	%	Barrel	%	Water condition	%	Tyres	%
Algarbi	31	8	25.8	4	12.9	5	16.1	14	45.2
Alganobi	28	3	10.7	9	32.1	1	3.6	15	53.6
Ganees East	18	3	16.7	1	5.6	0	0.0	14	77.8
Alserao	22	6	27.3	5	22.7	4	18.2	7	31.8
Almadina -1	13	3	23.1	2	15.4	0	0.0	8	61.5
Sika hadeed	19	9	47.4	3	15.8	5	26.3	2	10.5
Alzehour	27	12	44.4	8	29.6	1	3.7	4	14.8
Almadina -2	25	11	44.0	5	20.0	0	0.0	6	24.0
Aleuona	18	6	33.3	4	22.2	0	0.0	4	22.2
Almadina-4	14	6	42.9	5	35.7	0	0.0	0	0.0
Total	**215**	**67**	**31.2**	**46**	**21.4**	**16**	**7.4**	**74**	**34.4**



	Algarbi	Alganobi	Ganees East	Alserao	Almadina -1	Sika hadeed	Alzehour	Almadina -2	Aleuona	Almadina-4
Zeer	25.8	10.7	16.7	27.3	23.1	47.4	44.4	44	33.3	42.9
Barrels	12.9	32.1	5.6	22.7	15.4	15.8	29.6	20	22.2	35.7
watercondition	16.1	3.6	0	18.2	0	26.3	3.7	0	0	0
Tyres	45.2	53.6	77.8	31.8	61.5	10.5	14.8	24	22.2	0

Fig. 1: Types of water containers harboring *Aedes aegypti* mosquito in Blue Nile State 2023

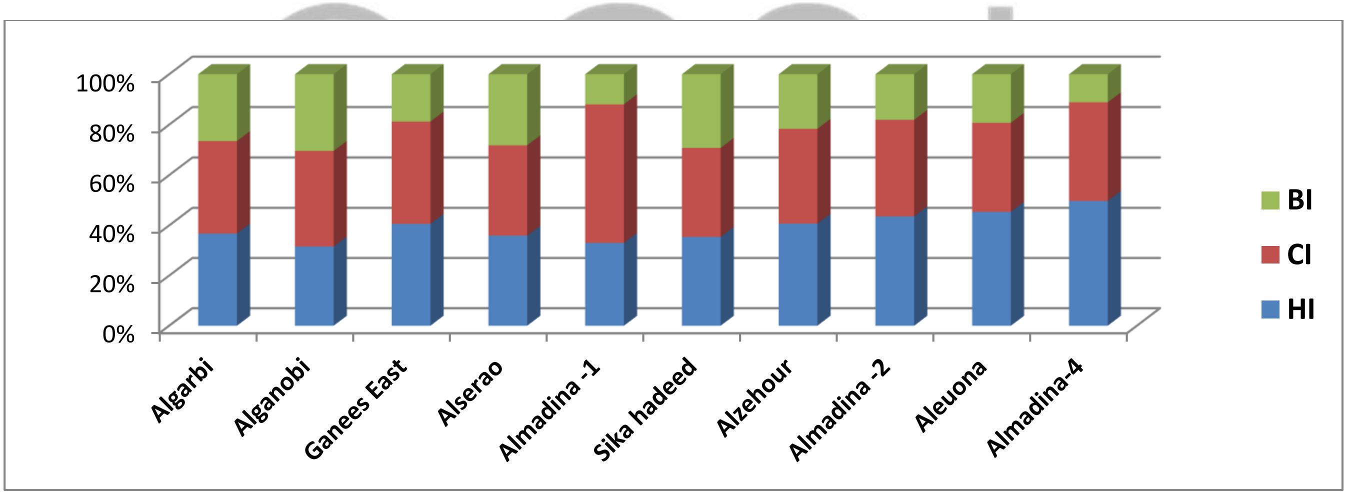


Fig. 2: *Aedes aegypti* mosquito indices in different areas, Blue Nile State 2023

DISCUSSION:

The current study showed that the *Aedes aegypti* was only species found in the selected sites in different water storage containers of Blue Nile State. This because of suitable environment in urban areas the state and also may be attributed to the latest invasion of *Aedes aegypti* from all States of Sudan except the Northern State. Also invasion from neighboring countries may take place, in addition to the huge displaced from Khartoum due to War conflict on 15th of April 2023. In accordance study stated that *Ae. aegypti* is the most common species along the increasing urbanization gradient and the unique *Aedes* species in urban settings (9). Our study showed that from a total of 50 houses in Surveyed areas of Blue Nile a number of 47 houses were found positive (94%) with a total of 215 different types of water containers inspected with 202 positive water containers that represent 94% also. Similar findings were previously reported in Dar es Salaam (5, 10). In comparison, Mboera *et al*. found five mosquito species in the same district in a study conducted during the dengue outbreak of 2014/2015 (5). The study by Mboera *et al*. was conducted during the long rainy season (April–May) (5), compared with this study that was carried out during the end of a short rainy season (December) and the beginning of the dry season (January). The effect of seasonal variations on the abundance and distribution of Aedes mosquitoes has been reported by other authors (11, 12). Also, *Ae. aegypti* has also been reported as a common outdoor breeding mosquito in the rural areas of Tanzania (13). Hence the study indicated that the Aedes entomological indices were found very high that reflects the invasion of the surveyed areas with *Aedes aegypti*. The House index (HI) was found 94% which ranged between 60-100% in the study areas. While the container index was found 94% with range between 78.6-100%. However the Breatu index (BI) was found to be 49.3% with range from 22.4-82.6%. The pupal per residence in the surveyed areas was 3.2 with range of 1.6-3.6. A result from a study in northern Ghana also showed higher house indices ranging from 55.9% to 88.3% (34). The overall container index in the current study was higher than previously reported (8). 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 (14). High *Aedes* mosquito indices reported in this study were not surprising as the study was carried out during the end of the short rainy and the start of the dry season (15). The high Breteau index reported in this study indicates that the residents of Kinondoni are likely to be at high risk of dengue virus transmission (16). These findings agree with the results reported from a study in northern Ghana, where Breteau indices of 72.4 to 180.9 were reported during a dry season (14). On the other hand the study showed that from 215 water containers inspected; a number of 67 (31.2%) were zeer, 46 (21.4%) were barrels; 16 (7.4%) were water condition and 74 (34.4%) were tyres. The most containers inspected harboring *Aedes aegypti* mosquito were tires (34.4%) followed by zeer (31.2%). Similarly, a previous study found that water-holding containers left outdoors were harbouring *Aedes* immature stages in Kinondoni and other districts of Dar es Salaam (8). The shortage of water supply may have led to many households keeping containers for water storage in their houses. Furthermore, the flower pots that retain water and improper disposal of used tires are likely to provide suitable sites for *Aedes* mosquito breeding. These factors probably contributed to the high number of breeding sites that favoured high *Aedes* abundance (17).

CONCLUSION:

This study confirmed the presence and abundant *Ae. aegypti* mosquitoes and a large proportion of water-holding containers infested with larvae and pupae in Blue Nile State, Sudan, suggesting that residents of the State are at higher risk of DENV transmission. Although DENV was not detected, our findings ascertain the need for continuous mosquito vector surveillance in Blue Nile State to guide strategies for appropriate vector control to prevent the possibility of near future DENV outbreaks. Therefore there is a need to improve *Aedes* mosquito control practices in the State to reduce the risk of DENV transmission.

DECLARATION OF COMPETING INTEREST:

The authors declared that there is no conflict of interest.

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