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Amanuel Mhretab Weldu
Entomologist, Ministry of Health Gash Barka Region, Eritrea

Awet Mebrahtu
Public Health Officer, Ministry of Health Gash Barka Region, Eritrea

Ibrahim Yakob
Public Health Officer, Ministry of Health Gash Barka Region, Eritrea

Corresponding Author:
Amanuel Mhretab Weldu
Entomologist, Ministry of Health Gash Barka Region, Eritrea

Assessment of container breeding preference, distribution and composition of human biting mosquitos (Diptera: Culicidae) larvae within the urban and semi-urban sites of the Gash Barka zone, Eritrea

Amanuel Mhretab Weldu, Awet Mebrahtu and Ibrahim Yakob

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Abstract
Mosquito-borne diseases, particularly malaria, pose a significant public health threat globally. Affecting nearly half the world's population, malaria is most prevalent in Sub-Saharan Africa, including Eritrea's Gash Barka Zone. This region accounts for 80% of the country's annual malaria cases, with over 67% of its population living in high-risk areas. To understand mosquito breeding patterns and inform control strategies, a cross-sectional study was conducted in Gash Barka Zone. This study surveyed mosquito larvae in various artificial containers across six districts (three urban and three semi-urban) from September to December 2020. A total of 2,570 containers were inspected, with 358 found positive for mosquito larvae. The study identified two dominant mosquito species: *Aedes* (8.7%) and *Anopheles* (5.4%). Notably, the survey revealed a higher prevalence of artificial containers harboring mosquito larvae in urban areas compared to semi-urban settings. Additionally, *Aedes* larvae exhibited a preference for breeding in urban environments. These findings highlight the importance of identifying mosquito breeding habitats for effective control of mosquito-borne diseases like malaria, dengue, and chikungunya**.** By understanding mosquito breeding preferences and distribution patterns, targeted interventions can be implemented to reduce mosquito populations and ultimately, disease transmission.

Keywords: Human biting, Gash barka, urban and semi-urban

Introduction

Background: Mosquitoes are important vectors for pathogens of humans and other vertebrate animals. Some aspects of adult mosquito behavior and mosquito ecology play an important role in determining the capacity of vector populations to transmit pathogens. Mosquitoes transmit the pathogens that cause malaria, filariasis, dengue, and other diseases that account for approximately 17% of the global burden of infectious diseases. Mosquito-borne pathogens are transmitted while mosquitoes probe or blood feed, so the intensity of transmission and the risk of infection are related to blood feeding behaviors and population density of local populations of vector mosquitoes (Wu, S.L, *et al*. 2020) [18].

Human malaria parasites are transmitted by mosquitoes of the genus *Anopheles* and their geographic distribution is the result of a complex interaction of biogeography, including biotic (e.g. competition and dispersal) and abiotic factors (e.g. climate and topography) that can vary in both time and space. Africa has over 140 recorded *Anopheles* species, of which at least eight are considered to be effective vectors of malaria (Gillies, M.T. and Coetzee, M., 1987 and Gillies, M.T. and De Meillon, B., 1968) [6, 7]. Two of the most efficient vectors of human malaria, *Anopheles* gambiae sensu stricto (hereafter An. gambiae) and *Anopheles* arabiensis (White, G.B., 1974) [15] are members of the An. Gambiae complex. Other recognized species of the complex are *Anopheles* merus, *Anopheles* melas, *Anopheles* quadriannulatus, *Anopheles* quadriannulatus B and *Anopheles* bwambae. *Anopheles* merus and An. melas are along the eastern and western coasts of Africa, respectively, while An. bwambae has only been found breeding in mineral springs in the Semliki forest in Uganda (Coluzzi, M., 1984) [1].

Anopheles quadriannulatus, found in south-east Africa (Coluzzi, M., 1984) [1] and *An. quadriannulatus* B, which has been described in Ethiopia (Hunt, R.H., *et al.* 1988) [10] are not considered vectors of human malaria as they are generally zoophilic (Coluzzi, M., 1984) [1]. In addition to the An. gambiae complex, other species known to be important in malaria transmission in Africa include *Anopheles* nili, *Anopheles* moucheti and *Anopheles* funestus which belongs to the Funestus group of which there are two African subgroups (Funestus subgroup includes *Anopheles* aruni, *Anopheles* confusus, *Anopheles* funestus, *Anopheles* parensis, *Anopheles* vaneedeni; Rivulorum subgroup includes *Anopheles* brucei, *Anopheles* fuscivenosus, *Anopheles* rivulorum, and An. rivulorum-like species) (Gillies, M.T. and Coetzee, M., 1987 and Harbach, R.E., 2004) [6, 8]. Other species, such as *Anopheles* paludis, *Anopheles* mascarensis and *Anopheles* hancocki play only a limited, secondary and localized role where they are found (Fontenille, D. and Simard, F., 2004 and Okara, R.M, *et al*. 2010) [5, 11].

Studies on vector bionomics in gash barka have not been done the last three years. The last time a survey on vector bionomics was conducted in 2017 in three sub zones of gash Barka specifically for the *Anopheles*' mosquito. And it should be done every two years but it was not done through the last four years this is because of the pandemic corona vires. Species composition and abundance that was studied in 2017 may have shifted over time due to intensive indoor insecticide pressure with LLINs and IRS use.

The activity plan is aimed at strengthening entomological activity and to assess the presence of different type of mosquito post IRS. The survey will be conducted in five sub zone during the summer in September & repeated during dry season in December.

Problem Statements

Malaria is getting reduced and reduced from time to time from gash Barka zone, because more efforts have been done by the community as well as the government especially in the reduction of mosquito breeding habitats and spraying insecticides to the selected malarious area of the zone however at the recent years starting from 2018 the trend of malaria starts to increase even though the activities of IVM were going on. So that the adaptation of *Anopheles*' mosquitoes to breed in containers that means indoor may change the success that we have achieved over the past years. In addition to this, the invasion of urban sites by *An. Stephensi* in our neibouring countries have been created a lot of burden and caused uncontrolled epidemics in different countries like Djibouti starting from 2012 and annually ever since (Sinka, 2020) [13]. More over the cause of the re-establishment of malaria in Sri Lanka after 5-years of zero malaria transmission is *An. stephensi* (WHO, 2019) [16]. So this study will identify the species invading containers including *Culex, Aedes* and *Anopheline* and will come-up with proactive suitable strategies. And will be a base for the integration of urban mosquito surveillance with the routing entomological surveillance conducting in our area.

General Objective

Assess the presence and compositions of the human biting mosquito larvae and determine their preference for breeding containers in six sentinel sites of the Gash Barka Zone (Tesseney, Barentu, Akordat, Forto Sawa, Mogolo, and Tokombia) from September to December 2020.

Specific objectives

- To determine mosquito vector species composition and abundance in Tesseney, Forto sawa, Mogolo, Laelay gash, Barentu & Akordat sub zone
- To determine the preference of indoor breeding habitats of the mosquitos
- To compare and determine the availability of all types mosquitos in one breeding container.
- To compare the distribution and abundance of the human biting mosquito in urban and semi-urban areas

Key words

Mosquito (*Anopheles*, *culex* and *Aedes*), larvae, breeding habitat, containers, urban and semi-urban

Methods and Materials

Research Methodology

Study design

The study aimed to determine the distribution and composition of human-biting mosquito species in three urban (Barentu, Tesseney, and Akordat) and three semi-urban (Forto-sawa, Tokombia, and Mogolo) towns of the Gash Barka Zone, Eritrea, from September to December 2020. A cross-sectional survey was conducted, collecting mosquito larvae from various man-made containers (e.g., barrels, tires) within selected households at each site using standard World Health Organization (WHO) methods (n = 100 households per site). Larvae were reared to adults for species identification using morphological identification key. Additionally, a portion of un-reared larvae (n = 10%) were preserved in 70% alcohol for further analysis.

Study area

Gash Barka Zone (GBZ) is the largest and most malarious zone in Eritrea, with a population of 912,026. Located in the rich savanna region, it's the nation's main economic area, housing numerous large dams for agricultural projects and mining companies. The population primarily relies on agriculture, trading, and animal rearing. The zone experiences a rainy season from late June to October, receiving an average annual rainfall of 260.3 mm. Temperatures range from 16.9 °C to 37.8 °C, with an average relative humidity of 38-68%.

The presence of the dominant malaria vectors like [anopheline species] and the zone's climate, characterized by warm temperatures, humidity, and seasonal rainfall, contribute to its high malaria burden.

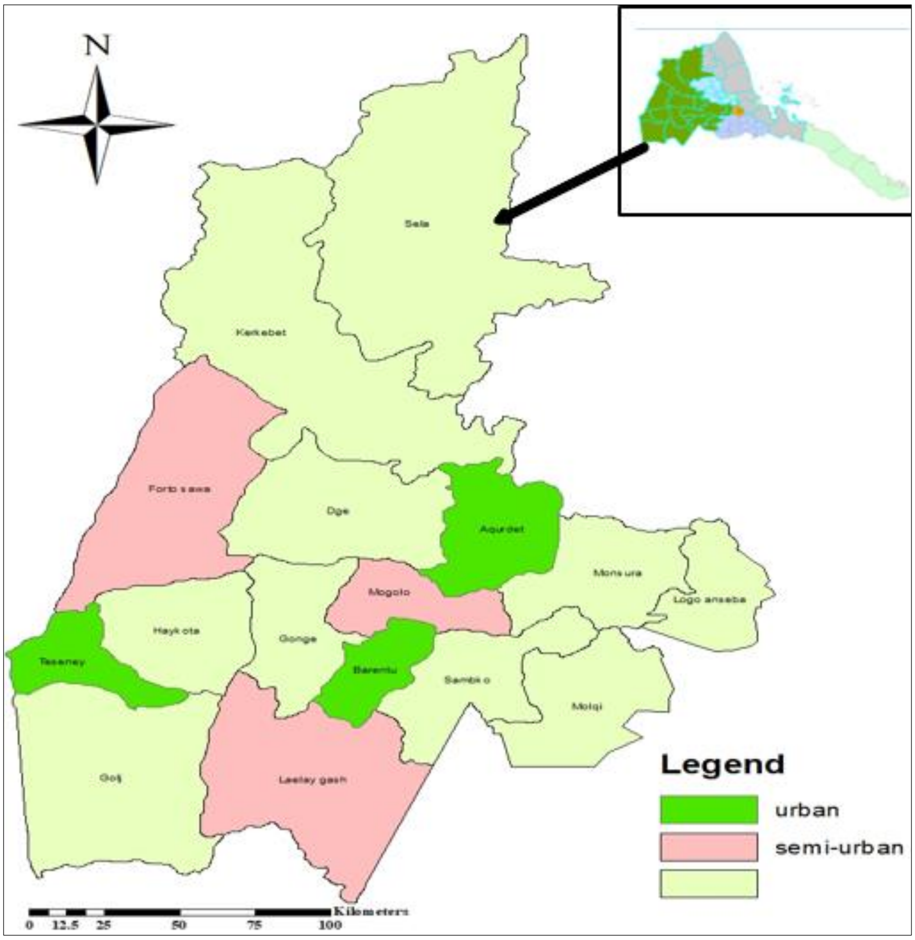

Fig 1: Map of gash barka zone by districts

Study site

Akordat

It is the largest town in the Akordat sub-zone, it lies in the main road of the Gash Barka zone and Akordat is the center of trade in the sub-zone with a population of 22,048 and the economic income depends mostly on farming, agriculture, animal raising, and small part of them are merchants. Akordat is situated along Barka River where is permanent breeding site. Akordat is found in the border with sub zones Mogolo, Dighe, Kerkebet, Mensura and Hagaz from Anseba zone. Akordat lies at latitude 15,551174" N and longitude 37.886464" E.

Barentu

It is the largest town in the sub-zone and center of the gash barka zone, it is surrounded by small mountains in its all directions and small rivers pass in both sides of the town and becomes the main breeding habitat for mosquito. With a population estimated to 34,000 and the economic income depends mostly on trading and same on farming and animal raising. Barentu is situated in the main road Asmara to Tesseney. Barentu is found in the bordering with subzones Laelay gash, Gogne, Shambiko, and Mogolo. Barentu lies at latitude 15107'95" N and longitude 375864'46" E.

Tesseney

It is the center of the sub zone Tesseney, it lies in the western part of the Gash Barka and Tesseney is the center of trade in the sub-zone known as land port. with a population of more than 30,000 and the economic income depends mostly on farming and animal raising, and small part of them are merchants. Tesseney is situated along Gash River where is permanent breeding site. Tesseney is found in the border with Sudan in the west, and with Goluj, Haykota and Forto Sawa in the Southeast and north respectively. Tesseney lies at latitude 14019'23" N and longitude 366543'68" E.

Mogolo

It is the largest town in the sub-zone, it lies in the main road of the Gash Barka to Asmara, with a population of 5,000 and the economic income depends mostly on farming and animal raising, and small part of them are merchants. Mogolo is situated along the road Barentu to Akordat and a small river pass beside of the town and it is the main breeding habitat. Mogolo is found in the border with the sub zones of Barentu Akordat Shambiko, Dighe and Gogne. Mogolo lies at latitude 153147'3" N and longitude 376467'85" E.

Tokombia

It is the second largest town in the L/gash sub-zone, it lies in the southern part of the Gash Barka and Tokombia is the center of trade in the sub-zone with a population of 10,000 and the economic income depends mostly on farming and animal raising, and small part of them are merchants. Tokombia is situated along Gash River where is permanent breeding site. Tokombia is found in the border with Ethiopia in the south and Goluj, Tesseney, Haykota, Barentu and Shambiko in the remaining sides of the subzone. Tokombia lies at latitude 1635517 N and longitude 37+336054 E.

Forto-Sawa
It is the largest town in the Forto sub-zone, it lies in the western part of the Gash Barka and Forto is the center of trade in the sub-zone with a population of 10,000 and the economic income depends mostly on farming and animal raising, and small part of them are merchants. Forto is situated along Small River where is permanent breeding site. Forto is found in the border with Sudan in the west and Kerkebet, Dighe, Haykota and Tesseney in the north, east, south and southwest respectively. Forto lies at latitude 14019'23" N and longitude 36039'8" E.

Study population
The population included in the study were all the collected mosquito larvae which were collected from indoor and outdoor breeding habitats of the study sites.

Sampling method
During the study simple random sampling techniques was used, from each collected mosquito larvae sample was taken for identification of the species composition in the study area.

Sample size
Using Simple random sampling technique 600 houses were selected for larvae collection from the six sites of study each of 100 households was inspected for the presence of any mosquito larvae from all possible wet containers found in their houses and the towns or semi-towns was clustered into administrative area in order to have proportional distribution on the number of houses to be surveyed according to the population of the administrative area.

Sampling techniques
Simple random sampling technique was used to select the 100 households from each study site. If the site selected for study had more than one Kebabi administration the sample size was collected proportionally depending up on the number of households using the following formula

The sample size will be determined using the following formula:

$$n^* = \frac{z^2 pq}{(d^2)} deff$$

Where:
n = the sample size
z = the critical value for achieving (1-α) % confidence level, here, z = 1.96. For 95% confidence interval.
p = the anticipated proportion. Here p = 0.5.
q = 1-p
d = the desired margin of error, we took d = 5%

Data collection
Data was collected from all the six sentinel sites using the standard WHO procedures. All the potential breading habitats which are found in the selected households will be sampled for the presence of larvae of different types of mosquito.

Larvae collection method
This study will use standardized dipping techniques to collect larval samples from various container types in each site. Morphological and molecular techniques will be employed for species identification. Container preference will be evaluated by comparing larval abundance across different types of container.

Data analysis
Data analysis will include descriptive statistics, correlation analysis, and potential cluster analysis to identify species composition and container preference patterns. This study aims to provide valuable information for developing targeted mosquito control strategies in the Gash Barka Zone by identifying dominant mosquito species, their breeding preferences, and potential hotspots for larval development

Fig 2: Types of containers inspected during the study survey in gash barka

Results
Over 2,500 artificial containers across six sentinel sites in Gash Barka Zone, Eritrea, were investigated for mosquito larvae breeding. These sites included both urban (Agordat, Barentu, and Tesseney) and semi-urban (Tokombia, Forto Sawa, and Mogolo) areas (Fig. 1). Of the surveyed containers, nearly 14% harbored at least one mosquito species (370 containers). As depicted in (Table. 1), the most frequent larval habitats were Plastic barrels (100), Metal tankers (55), Metal vessels (53), Cement cisterns (50), Mud pots (35), flower pots

(23) and the remaining others (basins, discarded tyres, discarded tin, Jerrycan, buckets and plant axels) (54) Interestingly, domestic containers like mud pots, grinding stones, metal containers, tires, and unused wells also played a role in mosquito breeding.

Outdoor environments appeared to be the primary breeding grounds. This likely stems from rainwater filling containers and residents storing water in cement cisterns and plastic drums. This study highlights the diverse range of container types that can serve as mosquito breeding sites in Gash Barka Zone. Understanding these preferences is crucial for implementing targeted mosquito control interventions and reducing malaria transmission.

Table 1: General distribution of container breeding habitat of mosquito larvae in Gash Barka study sites

Types of wet containers	# of wet containers inspected	# of containers found positive for larvae		Types of mosquito larvae found in the containers					
				Anopheles		*Aedes*		*Culex*	
		N	%	N	%	N	%	N	%
Plastic barrel	1251	100	8.0	26	2.1	65	5.2	9	0.7
Metal vessels	216	53	24.1	25	5.6	17	7.9	11	5.1
Mud pots	192	35	16.1	14	3.1	7	3.6	14	7.3
Cement cisterns	164	50	30.5	17	8.5	22	13.4	11	6.7
Metal tank	94	55	58.5	11	9.6	3	3.2	41	43.6
Bucket	78	3	3.8	0	0.0	0	0.0	3	3.8
Basin	58	6	10.3	4	3.4	1	1.7	1	1.7
Jerrycan	102	12	11.8	9	5.9	0	0.0	3	2.9
Discarded tin	9	0	0.0	0	0.0	0	0.0	0	0.0
Old tyres	11	0	0.0	0	0.0	0	0.0	0	0.0
Flower pot	347	23	3.7	6	1.7	10	2.9	7	2.0
Plant axel	21	2	9.5	0	0.0	1	4.8	1	4.8
Others	42	31	100.0	17	29.4	11	29.4	3	241.2
Total	2585	370	13.3	129	3.4	137	5.1	104	5.6

Table 2: Distribution of container breeding habitat of mosquito larvae in urban district (Agordat, Barentu and Tesseney)

Types of wet containers	# of wet containers inspected	# of containers found positive for larvae		Types of mosquito larvae found in the containers					
				Anopheles		*Aedes*		*Culex*	
		N	%	N	%	N	%	N	%
Plastic barrel	536	88	16.4	16	3.0	65	12.1	7	1.3
Metal vessels	151	37	24.5	12	8.0	17	11.3	8	5.3
Mud pots	155	20	12.9	6	3.9	7	4.5	7	4.5
Cement cisterns	127	41	32.3	14	11.0	19	15.0	8	6.3
Metal tank	34	30	88.2	9	26.5	3	8.8	18	52.9
Bucket	50	2	4.0	0	0.0	0	0.0	2	4.0
Basin	29	2	6.9	2	6.9	0	0.0	0	0.0
Jerrycan	45	9	20.0	6	13.3	0	0.0	3	6.7
Discarded tin	3	0	0.0	0	0.0	0	0.0	0	0.0
Old tyres	11	0	0.0	0	0.0	0	0.0	0	0.0
Flower pot	261	23	8.8	6	2.3	10	3.8	7	2.7
Plant axel	11	2	18.2	0	0.0	1	9.1	1	9.1
Others	25	19	76.0	5	20	11	44.0	3	12.0
Total	1438	273	19.0	76	5.4	133	9.3	64	4.5

Table 3: Distribution of container breeding habitat of mosquito larvae in semi-urban districts (Forto Sawa, Mogolo and Tokombia)

Types of wet containers	# of wet containers inspected	# of containers found positive for larvae		Types of mosquito larvae found in the containers					
				Anopheles		*Aedes*		*Culex*	
		N	%	N	%	N	%	N	%
Plastic barrel	715	12	1.7	10	1.4	0	0.0	2	0.3
Metal vessels	65	16	24.6	13	20.0	0	0.0	3	4.6
Mud pots	37	15	40.5	8	21.6	0	0.0	7	18.9
Cement cisterns	37	9	24.3	3	8.1	3	8.1	3	8.1
Metal tank	60	25	41.7	2	3.3	0	0.0	23	38.3
Bucket	28	1	3.6	0	0	0	0.0	1	3.6
Basin	29	4	13.8	2	6.9	1	3.5	1	3.5
Jerrycan	57	3	5.3	3	5.3	0	0.0	0	0.0
Discarded tin	6	0	0.0	0	0.0	0	0.0	0	0.0
Flower pot	86	0	0.0	0	0.0	0	0.0	0	0.0
Plant axel	10	0	0.0	0	0.0	0	0.0	0	0.0
Others	17	12	70.6	12	70.6	0	0.0	0	0.0
Total	1147	97	8.5	53	3.8	4	0.4	40	3.5

Urban areas in Gash Barka Zone appear to have higher mosquito breeding activity compared to semi-urban areas. This is evident from Tables 2 and 3, which show that 273 containers were positive for mosquito larvae in urban areas compared to 97 in semi-urban areas.

The types of containers serving as breeding sites also differ between urban and semi-urban settings. In urban areas, plastic barrels are the most common mosquito breeding habitat, followed by cement cisterns, metal vessels, and metal tankers. Conversely, in semi-urban areas, metal tankers are the most frequent breeding sites, followed by metal vessels, plastic barrels, and mud pots.

These differences may be linked to the lifestyles of residents in each area. The higher prevalence of artificial containers like plastic barrels and cement cisterns in urban areas likely provides more breeding opportunities for mosquitoes compared to the more diverse container types found in semi-urban areas. This, in turn, could explain the higher abundance of *Aedes* mosquitoes in urban areas, as they are known to prefer breeding in artificial containers.

Table 4: Distribution of mosquito larval species collected in the study area

Sites	Type of mosquito larvae	Productivity rate	Plastic barrel	Metal vessel	Mud-pots	Cement cisterns	Metal tanker	Bucket	Basin	Jerrycan	Old tyre	Flower pot	Plant axel	Others	Total
Urban area	*Aedes*	Positive containers	65	17	7	19	3	0	0	0	0	10	1	11	123
		# Of larvae collected	5970	1207	780	2731	265	0	0	0	0	153	300	5	11411
		Productivity rate	91.8	71.0	111.4	143.7	88.3	0.0	0.0	0.0	0.0	15.3	300.0	5.0	92.8
	Culex	Positive containers	7	8	7	8	18	2	0	3	0	7	1	3	63
		# Of larvae collected	977	1611	1695	2770	4445	0	0	254	0	378	660	600	13390
		Productivity rate	139.6	201.4	242.1	346.3	246.9	0.0	0.0	84.7	0.0	54.0	660.0	300.0	212.5
	Anopheles	Positive containers	16	12	6	14	9	0	2	6	0	6	0	5	72
		# 0f larvae collected	447	1110	147	2073	3826	0	10	170	0	160	0	460	8403
		Productivity rate	27.9	92.5	36.8	148.1	546.6	0.0	5.0	28.3	0.0	26.7	0.0	92.0	116.7
Semi-urban area	*Aedes*	Positive containers	0	0	0	3	0	0	1	0	0	0	0	0	4
		# Of larvae collected	0	0	0	1568	0	0	35	0	0	0	0	0	1603
		Productivity rate	0.0	0.0	0.0	0.0	0.0	0.0	35.0	0.0	0.0	0.0	0.0	0.0	400.8
	Culex	Positive containers	2	3	7	3	23	1	1	0	0	0	0	0	40
		# Of larvae collected	2100	435	451	250	2500	712	104	0	0	0	0	0	6552
		Productivity rate	1050.0	145.0	64.4	83.3	108.7	712.0	104.0	0.0	0.0	0.0	0.0	0.0	163.8
	Anopheles	Positive containers	10	13	8	3	2	0	2	3	0	0	0	12	53
		# Of larvae collected	467	808	155	159	97	0	8	87	0	0	0	0	1781
		Productivity rate	46.7	62.2	19.4	53.0	48.5	0.0	4.0	29.0	0.0	0.0	0.0	0.0	33.6

Distribution of mosquito larval species collected in the study area: A survey of mosquito larvae in the study area revealed variations in both abundance and distribution across species and locations (Table 4). *Culex* emerged as the most prevalent species, accounting for 46.2% of the collected larvae, followed by *Aedes* at 30.2%. *Anopheles* larvae were the least abundant, representing only 23.6% of the total.

However, the distribution of these mosquito species differed significantly between urban and semi-urban areas. *Anopheles* larvae exhibited a strong preference for urban habitats, with 82.5% found in these areas compared to 17.5% in semi-urban settings. Similarly, a higher proportion of *Aedes* larvae were collected in urban areas (87.8%) compared to semi-urban areas (12.2%). *Culex*, however, showed a less pronounced difference, with 67.1% found in urban areas and 32.9% in semi-urban areas.

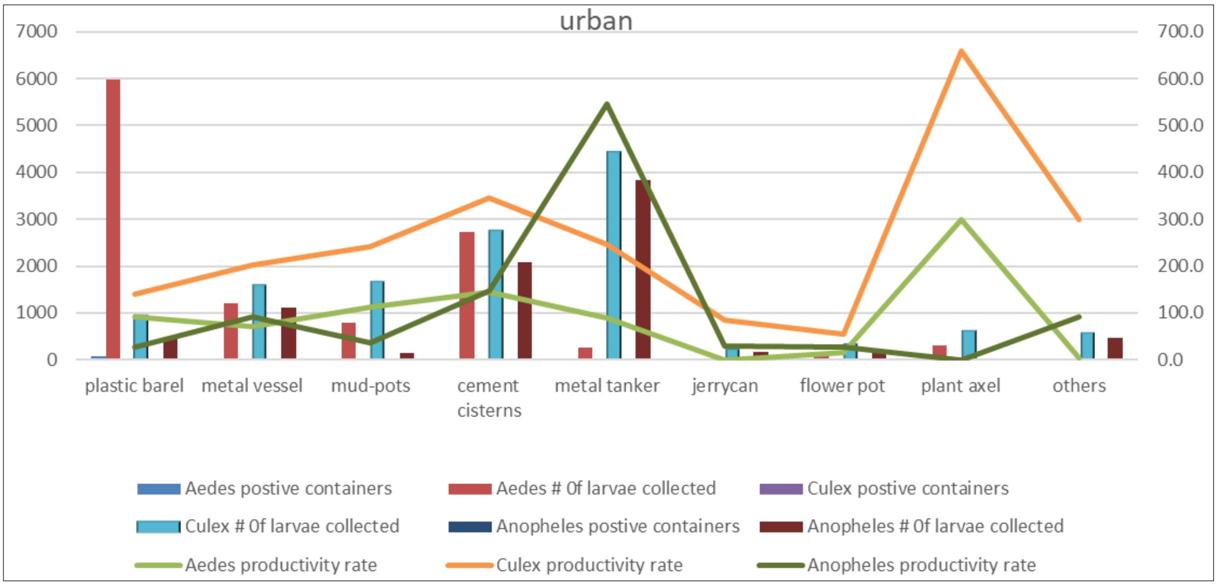

Fig 3: Distribution of mosquito larvae Vs. containers and their productivity rate in urban areas.

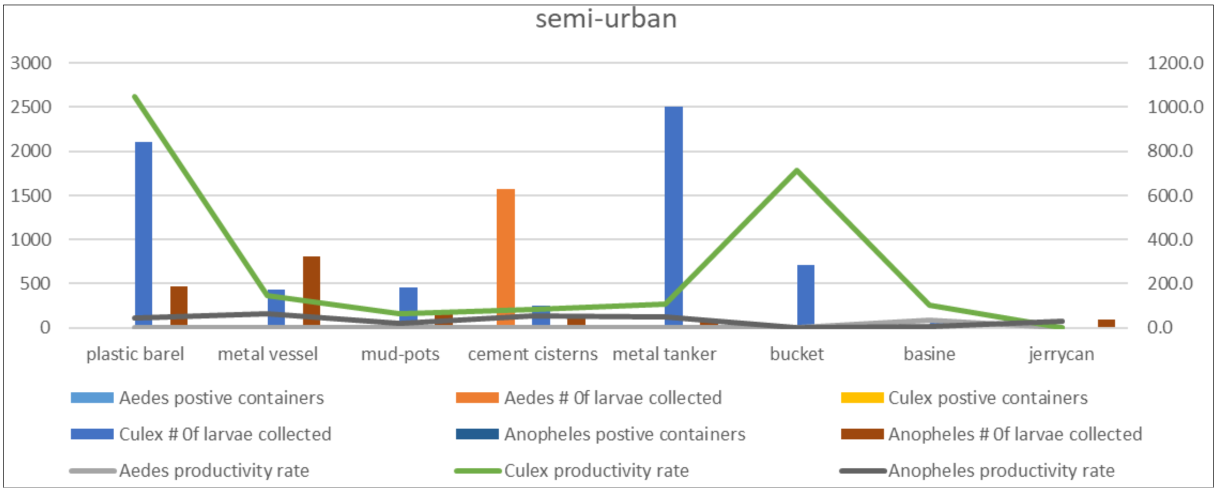

Fig 3: Distribution of mosquito larvae Vs. containers and their productivity rate in semi-urban areas.

Table 4: Comparison of mosquito larvae collected by container type and productivity rate of the containers in urban and semi-urban districts

Sites	Productivity rate	Plastic barrel	Metal vessel	Mud-pots	Cement cistern	Metal tanker	Bucket	Basin	Jerrycan	Old tyre	Flower pot	Plant axel	Others	Total
Urban total	Sum of positive containers	88	37	20	41	30	2	2	9	0	23	2	19	273
	Sum 0f larvae collected	7394	3928	2622	7574	8536	0	10	424	0	691	960	1065	33204
	Productivity rate	84.0	106.2	131.1	184.7	284.5	0.0	5.0	47.1	0.0	30.0	480.0	56.1	128.7
Semi-urban total	Sum of positive containers	12	16	15	9	25	1	4	3	0	0	0	12	97
	Sum 0f larvae collected	2567	1243	606	1977	2597	712	147	87	0	0	0	0	9936
	Productivity rate	213.9	77.7	40.4	219.7	103.9	712.0	36.8	29.0	0.0	0.0	0.0	0.0	102.4
Total	Sum of positive containers	100	53	35	50	55	3	6	12	0	23	2	31	370
	Sum 0f larvae collected	9961	5171	3228	9551	11133	712	157	511	0	691	960	1065	43140
	Productivity rate	99.6	97.6	92.2	191.0	202.4	237.3	26.2	42.6	0.0	30.0	480.0	34.4	116.6

The study also assessed the productivity of mosquito breeding sites in Gash Barka Zone. A total of 43,140 larvae were collected from 370 containers, resulting in an average of 116.6 larvae per container. Urban areas exhibited higher larval productivity compared to semi-urban areas. This is evident from the following findings:

- **Total larvae collected:** Urban (33,204) vs. Semi-urban (9,936).
- **Total Containers positive for larvae:** Urban (273) vs. Semi-urban (97).
- **Average larvae per container:** Urban (128.7) vs. Semi-urban (102.4).

Within each setting, specific container types emerged as the most productive breeding sites: In urban areas the more productive container is plant axels (480) followed by metal tankers, cement cisterns, mud-pots, and metal vessels (284.5, 184.7, 131.1 and 106.2) larvae per container. In the semi-urban aspect, the higher productive container was bucket (712) followed by cement cisterns, plastic barrel, metal tanker and metal vessels (219.7, 213.9,103.9 and 77.7) larvae per container respectively. During the survey time containers like old tyre and discarded tin were found to be negative for all types of mosquito larvae.

The observed disparity in larval productivity between urban and semi-urban areas warrants further investigation. One potential explanation could be differences in water storage practices. Urban residents might collect and store larger volumes of water for domestic use, creating more potential breeding sites compared to semi-urban areas.

This finding underscores the importance of targeted social mobilization efforts to address mosquito control in Gash Barka Zone. Here are some key considerations:

- **Focus on urban communities:** As they exhibit higher larval productivity, urban communities should be a primary target for interventions aimed at raising awareness and promoting responsible water management practices.
- **Promote proper handling of water containers:** Educational campaigns can emphasize the importance of covering, emptying, and cleaning water storage containers to prevent mosquito breeding.
- **Community engagement:** Involving community leaders and residents in the design and implementation of control strategies can foster ownership and ensure long-term sustainability.

By implementing these targeted interventions, communities in Gash Barka Zone can effectively combat mosquito breeding and reduce the risk of mosquito-borne diseases.

Discussion and Recommendations

This study examined the abundance and distribution of mosquito larvae in both urban and semi-urban areas of Gash Barka Zone, Eritrea, focusing on the types of artificial containers preferred for breeding. The findings revealed the presence of three mosquito genera: *Aedes*, *Anopheles*, and *Culex*. This diversity suggests that the climatic and environmental conditions in Gash Barka Zone are suitable for supporting a range of mosquito species. A study done in northwestern part of Ethiopia reviles that artificial containers are found to be the main breading habitats of *Aedes* mosquito in urban areas (Ferede, G. *et al.*, 2018) [4]. Another study conducted in Sri Lanka strongly agree with the result obtained in our study artificial containers are more in urban than in semi urban followed by rural areas (Dissanayake, D.S. *et al.*, 2021 and Herath, J.M. *et al.*, 2024) [2, 9]. Study done in Nigeria also strongly agree with the result obtained in the study done in gash barka more larvae of *Aedes* mosquito were collected from urban comparing to the rural (Egwu, O. *et al.*, 2018) [2].

The source reduction is an effective way for the community to manage the populations of many kinds of mosquitoes (Rajesh, K; *et al*. 2013) [12]. The eradication of mosquito breeding containers or breeding sites in and around living, working areas should be taken into consideration, since the presence of water in containers is probably the most important factor in determining the breeding of mosquitoes, especially *Aedes* sp., *Culex* sp recently also *Anopheles stephensi*. As a result, a mosquito control programme should be established at gash Barka zone including indoor activities such as proper covering of water containers which are used for domestic purpose and proper removal of used container. Such a programme would reduce the risk to both animals and humans, and hence prevent the development of mosquito borne disease motivations in surrounding locations.

By implementing a combination of these strategies, communities in Gash Barka Zone can effectively reduce mosquito breeding sites and combat the spread of mosquito-borne diseases.

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