Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Effect of seasonal variation on the resting behavior of Aedes species (Diptera: Culicidae) in Metema district, Northwest, Ethiopia

wondmeneh jemberie

wondmeneh12@gmail.com

University of Gondar

Sisay Dugussa

Addis Ababa University

Abebe Animut

Addis Ababa University

Research Article

Keywords: Aedes species, resting habitat, seasonal variation, abdominal status

Posted Date: August 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10645953/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background: *Aedes*mosquitoes transmit several medically important viral diseases, including dengue fever, yellow fever, chikungunya, and Zika. These diseases have re-emerged as major global public health concerns due to increasing urbanization, rising temperatures associated with climate change, and intensified human mobility. Seasonal variation, particularly between the wet and dry seasons, influences the distribution and resting behavior of *Aedes*species in the Metema District of northwestern Ethiopia.

Method: Adult *Aedes*mosquitoes were collected from both indoor and outdoor resting habitats, including grain storage facilities, deep ground grooves, cattle shelters, water-holding containers, and under bridges. Collections were conducted using pyrethrum spray catches (PSC), Prokopack aspirators, and mouth aspirators. Captured mosquitoes were identified to species level under a stereomicroscope using standard morphological identification keys. Data were entered and analyzed using IBM SPSS Statistics version 20.0.

Results: A total of 4,054 adult *Aedes*mosquitoes were collected, comprising *Aedes aegypti* (3,026; 74.6%), *Ae. vittatus* (723; 17.8%), *Ae. communis* (186; 4.6%), *Ae. albopictus* (77; 1.9%), and *Ae. opok* (42; 1.0%). Significantly higher numbers of *Ae. aegypti* and *Ae. vittatus* were collected from cattle shelters than from other resting habitats ($P < 0.001$). Adult *Ae. communis* and *Ae. albopictus* were primarily collected from larva-positive water containers, whereas *Ae. opok* was predominantly collected from beneath bridges. The abundance of adult *Aedes*mosquitoes peaked during the wet season (June–September 2023). In contrast, during the dry season (October–May), *Aedes* mosquitoes were mainly found resting in deep ground grooves and beneath bridges. A high proportion of blood-fed *Aedes* mosquitoes was collected from cattle shelters. The predominance of *Ae. aegypti* and *Ae. vittatus* in cattle shelters during the wet season is likely associated with the availability of carbon dioxide, host body heat, and protection from adverse environmental conditions. During the dry season, the resting behavior of *Aedes*mosquitoes shifted toward moisture-retaining habitats, such as deep ground grooves and the undersides of bridges.

Conclusions These findings highlight the importance of implementing targeted *Aedes*mosquito control strategies that account for seasonal variation and resting habitat preferences. Particular emphasis should be placed on managing key resting sites in urban areas, especially cattle shelters during the wet season and moisture-retaining refuges during the dry season. Strengthening entomological surveillance and implementing seasonally targeted vector control interventions could substantially reduce the risk of *Aedes*-borne viral disease transmission in the Metema District, northwestern Ethiopia.

Introduction

Some species of *Aedes* mosquitoes transmit viral pathogen such as dengue, Zika, chikungunya and yellow fever virus that affect human health and economic activities in tropical and subtropical regions of the world[1]. However, low attention is paid to the viral cause of diseases in Africa due to a number of factors including lack of diagnostic facilities [2], lack of vaccines or antiviral treatments [3] and

economic challenges in allocating resources for control and prevention [4]. Furthermore, as some of these diseases are rarely lethal, they might be viewed as less serious [5]. *Aedes* mosquitoes' surveillance and control is regarded as the most effective way for combating arboviral diseases. Nonetheless, the diseases are on the rise globally because of the increasing unplanned urbanization, temperature [6, 7], human mobility and poor water management or sanitation systems [8, 9].

In recent years, several arboviral diseases most notably yellow fever, dengue, and chikungunya outbreaks occurred in Ethiopia [10–13]. YF outbreak was first reported in the southwest of the country between 1960 and 1962 that caused 100,000 cases and 30,000 deaths [3]. Then after, YF outbreak took place between 2012 and 2013 in South Omo [14, 15]. Another YF outbreak in Wolaita Zone claimed the lives of 10 individuals [16]. More recently, YF outbreak occurred in the Gurage Zone [9]. Repeatedly, dengue and chikungunya outbreaks have been documented in the eastern part [17, 18] such as in Dire Dawa town where the first dengue outbreak infected more than 11,000 individuals [12] and the recent chikungunya outbreak infected over 40,000 individuals [19]. Additionaly, Zika virus (ZIKV) was detected in the Gambella region of southwest, Ethiopia, with 27.3% of samples testing positive for ZIKV IgG antibodies [20] Moreover, CHIKV was detected at the teaching hospital in the border line contry in Kassal region, east sudan [21]. In the study site, there have also been reports of chikungunya and dengue infections occured in Metema District, northwestern Ethiopia [11, 22].

Aedes species are widely distributed across the globe including Ethiopia [11, 23] and adapted to urban, peridomestic and rural habitats [24]. *Aedes* species bread in both temporary and permanent water bodies and the adults typically rest in micro climatically suitable habitats that help minimize physiological stress. Small-scale temperature differences contributed to mosquito resting site selection in Germany [25]. Almost all *Ae. simpsoni* complex collections were made during wet seasons resting in the leaves of the Abyssinian banana in southwest Ethiopia [26] *Ae. aegypti, Ae*. *hirsutus* and *Culiseta longiareolata* were abundant during wet seasons, most resting indoors, in the Somalia region [23]. Recently, five *Aedes* species have been identified at the study site including *Ae. aegypti, Ae. vittatus, Ae. communis, Ae. albopictus*, and *Ae. opok*. They are distributed across both artificial and natural breeding habitats [27, 28].

Currently, the distribution of *Aedes* species in the wide regions and uncertainty time outbreak of arboviral diseases are common in Ethiopia. However, information on the bionomic characteristics of *Aedes* mosquitoes in the district is scarce, and limited attention has been given to entomological monitoring and surveillance to identify appropriate vector control tools for outbreak prevention and control. For this reason, the study was conducted to assess the effect of seasonal variation on the distribution of *Aedes* species at different resting places in the dry and wet seasons in the Metema district of northwestern Ethiopia. This outcome supplies to essential baseline knowledge to development control of *Aedes* species distribute and arbovirus transmission.

Materials and Methods

Study sites

The study was conducted in Metema-Yohannes, Kokit and Genda-Wuha towns, Metema district, Northwestern Ethiopia. The towns are described in previously published articles [28, 29].

Study design

The study towns were selected on the basis of dengue fever and chikunganya case reports in the district. Additionally, entomological data showed that *Aedes* species found in the study sites. A longitudinal prospective study were designed to *Aedes* mosquito samples were collected for three consecutive days per month for 12 consecutive months, from January 2023 to December 2023. Adult *Aedes* species were employed from potential resting habitats including indoor (main, bed and kitchen room) and outdoor (cattle shelter, grain stotrage, inside larvae breeding container, deep groove and underside bridge) (Fig. 1). In the wet season had moderate temperature ranges (24.6–27.7°C) and high humidity levels (71.5–75.4%) from June to September. Moreover, *Aedes* mosquitoes resting microhabitats had temperature and humidity variation at deep groove with filled water and also underside of bridge had water flows. Whereas, in the dry season from October to May had suitable resting places at deep groove and underside of bridge due to retain miosture and humidity relative to other habitats. The study was conducted across selected residential houses to ensure comprehensive coverage of the study towns. A total of 327 houses were inspected in Metema-Yohannes town, of which 103 were positive; in Kokit, 298 houses were inspected with 82 positive cases; and in Gendawuha, 452 houses were inspected, yielding 92 positive cases. Adult mosquito sampling was carried out within a 200 meter radius of each reference house, targeting potential resting sites. Prior to conducting the survey, verbal consent was obtained from household heads.

Adult mosquito collection and processing

Adult mosquitoes were collected using mouth held aspirator (model 412, John W. Hock Company, Gainesville, FL, USA), pyrethrum spray sheet collection and Prokopack aspirator (John W. Hock Co., Gainesville, FL, USA, Model: 1419) [52, 53]. *Aedes* larvae samples survey were collected from artificial and natural breeding habitats and it published [28]. Parallel, adult *Aedes* species survey was employed from potential resting habitats including indoor (main, bed and kitchen room) and outdoor (cattle shelter, grain stotrage, inside larvae breeding container, deep groove and underside bridge) from positive houses. Specimens were collected in the morning (06:00–07:00am) according to WHO [23]. Each collected sample was kept individually in 1.5ml Eppendorf tube and transferred to zip-lock bag with silica gel (labeled with name of town, collection date, resting place and GPS points). The samples were transported to the Department of Biology, University of Gondar, Ethiopia for further analysis. The mosquitoes were identified to species level under stereo microscope following taxonomic keys [30–32]. In addition to *Ae. aegypti* and *Ae. vittatus* were identified by molecular technique from this study site.

They were sorted by genus, species, sex, abdominal status. Their abdominal status was classified as unfed (UF), blood fed (BF), semi-gravid (SG) or gravid (G).

Data Analysis

Data from the prospective study were analyzed using IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY), version 20.0. House infestation by adult *Aedes* mosquitoes was described using Stegomyia indices, specifically the Adult House Index (AHI), calculated as the number of infested houses divided by the total number of houses inspected [33]. The Resting Index (RI) was computed as the number of each *Aedes* species found at specific resting sites divided by the total number of *Aedes* individuals recorded in the study area. Species diversity was determined using the Shannon diversity index, expressed as $H = -\sum [Pi \times ln(Pi)]$, where H represents the diversity index, Pi the proportion of each species, and ln the natural logarithm. Evenness in species distribution was assessed using Pielou's evenness index ($J = H/ln(S)$), where S denotes the total number of species [34, 35]. The Mann–Whitney U test was used to compare the abundance of adult resting *Aedes* species between wet and dry seasons, while the Kruskal–Wallis H test was applied to assess differences in species distribution across the three towns and among different resting places. All statistical tests were considered significant at $p < 0.001$.

Ethical statement

The study was ethically approved by the institutional review board (IRB) of Aklilu Lemma Institute of Pathobiology, Addis Ababa University, Ethiopia with the reference number ALIPB IRB/79/2014/22. Additionally, written permission letters were obtained from the Metema Woreda (district) health bureaus and health centers.

Results

Composition and relative abundance of *Aedes* species

A total of 9,936 adult mosquitoes were collected from the study towns, representing the genera *Culex* (5,024; 50.5%), *Aedes* (4,054; 40.8%), *Anopheles* (702; 7.0%), and *Culista* (156; 1.5%) (Table 1). The highest number of mosquitoes was recorded in Metema-Yohannes (3,678; 37.02%), followed by Gendawuha (3,223; 32.4%) and Kokit (3,035; 30.5%). However, no statistically significant difference ($p > 0.001$) was observed in mosquito distribution among the three study towns. Of which 4,054 *Aedes* mosquitoes collected, 74.6% (3,026) were *Ae. aegypti*, 17.8% (723) *Ae. vittatus*, 4.6% (186) *Ae. comminus*, 1.9% (77) *Ae. albopictus*, and 1% (42) *Ae. opok*. A statistically significant difference in population size was observed among the five *Aedes* species across all study sites ($p < 0.001$).

During the study period, several malaria vector species were collected from the three towns, including *An. gambiae* (184/702; 26.21%), *An. stephensi* (135/702; 19.23%), *An. pharoensis* (53/702; 7.54%), *An. pretoriensis* (144/702; 20.51%), *An. christyi* (84/702; 11.96%), and *An. cinereus* (102/702; 14.52%). In

addition, the avian malaria vector *Culiseta longiareolata* was reported in Gendawuha and Kokit towns (Table 1).

Resting habitat of *Aedes* mosquitoes

A total of 4,054 resting adult *Aedes* mosquitoes were collected from both indoor and outdoor places in the study towns. Of these, 343 were collected indoors, including from the main room (147; 42.8%), bedroom (182; 54.5%), and kitchen (14; 4.1%). The highest numbers of *Ae. aegypti* (S1 Fig) and *Ae. vittatus* were recorded in bedrooms, with a statistically significant difference ($p < 0.001$) indicating a preference for indoor resting habitats. In contrast, *Ae. communis* was primarily collected from main rooms, with no statistically significant difference observed. However, *Ae. albopictus* and *Ae. opok* were not found in indoor resting habitats (Table 2).

A total 3711 *Aedes* species were collected from outdoor of which 3026 *Ae. aegypti*, 30.9% (936) were collected from cattle shelters, 28.8% (873) from inside larvae containers, 16.8% (510) from grain storage, 8.6% (262) indoors, 8.4% (255) under bridge and 6.5% (190) from deep groove. Similarly, 29.4% (213) *Ae. vittatus* was collected from cattle shelter, 28.9% (209) from discarded tyres, 21.8% (158) from grain storage, 8% (58) indoors, 6.9% (50) under bridge, and 4.8% (35) inside deep grooves. *Ae. communis* was found cattle shelter (46; 26.8%), tyre breeding container (43; 24.7%), grain storage (35; 17.74%), deep grooves (25; 10.75%) and under bridge (13, 6.98%). In addition, a higher number of *Ae. albopictus* were preferred tyre breeding containers (22; 33.7%) and follow by to cattle shelter (20; 22.0%), deep groove (17; 19.48%), local grain storage (10; 15.58%), bridge (8; 9.09%). Surprisingly, a higher number of *Ae. opok* was preferred to under bridge place (15; 35.7%) compared to the deep groove (11; 26.2%), cattle shelter (9; 21.4%), inside larvae ontainer (7: 16.6%), local grain storage (0; 0.0%) (Table 3 and S1 Table). From the total 4054 *Aedes* mosquitoes, 91.5% (3711) were found resting outdoors compared to the 8.5% (344) that were found resting indoors. The numbers of each *Aedes* species among the resting sties differed significantly ($P < 0.001$).

A total of 4054 *Aedes* mosquitoes representing five species were selected from the study sites. Of which 3630 and 424 were collected during wet and dry season respectively. The highest number of *Ae. aegypti, Ae. vittatus* and *Ae. communis* were collected at outdoor in the wet season when compare in the dry season. There was statistically significant different ($P< 0.001$) observed the number of *Ae. aegypti, Ae. vittatus mosquitoes* b/n in two seasons. However, *Ae. albopictus* and *Ae. opok* were not found indoor in both seasons (table 4).

House indices of adult *Aedes* species

A total of 1,077 inspected houses within 200m intervals were screened in Metema-Yohannes, Genda-Wuha and Kokit towns. Of which, 327 residential houses were marked in Metema-Yohannes and had observed 103 positive houses. *Ae. aegypti* (78%), had observed the highest house index and followed by *Ae. vittatus* (56%), *Ae. albopictus* (11%), *Ae. opok* (4%) and *Ae. communis* (0.0%). In Kokit town, 298 inspected houses were screened and 81 positive houses were observed. When compared five *Aedes*

species, *Ae. aegypti* (58%) had the highest house index and followed by *Ae. vittatus* (39%) and *Ae. communis* (9%). Similarly, in Genda-Wuha, 452 inspected houses were found of these 92 houses were positive. In this town, *Ae. aegypti* had an index of 72% followed by *Ae. vittatus* (44%) and *Ae. communis* (17%). Overall, *Ae. Aegypti* had the highest number of house index observed in Metema-Yohannes (78%), followed by Gendawuha (72%) and Kokit (58%).

Monthly catches of resting adult *Aedes* species

The highest numbers of adult *Aedes* mosquitoes (87.3%) were collected from June to September under average weather conditions of 72.7% relative humidity and 25°C temperature at resting sites in the study towns. In contrast, substantially fewer number of adult *Aedes* mosquitoes were collected from October to May during the study period, likely due to increased average temperatures ranging from 33-38°C and a sharp decline in relative humidity from 56.7-34%, which are less favorable conditions for mosquito survival and reproduction. The study area experiences a unimodal rainfall pattern from May to September, creating optimal temperature and humidity conditions for mosquito reproductive activities. In contrast, no rainfall was recorded from November to April throughout the study period (Fig. 2).

Abdominal status of *Aedes* species in relation to their resting sites

About 51.2% (2076) of the total *Aedes* mosquitoes caught from their resting habitats were females (S1 Table). Among the females, 90.7% (1885) were unfed, 5.7% (119) blood fed, 1.8% (39) semi-gravid and 1.5% (33) gravid (S1 Table). *Ae. aegypti* was the higest blood fed (68.9%; 82). Among these blood fed *Ae. aegypti*, 32.9% (27) were collected from animal shelters followed by grain storages (23; 28.1%), indoors (19; 23.2%), larval continers (6; 7.3%), deep grooves (4; 4.8%) and under bridge (3, 3.6%). Similarly, 45.8% (11) of the blood fed *Ae. vittatus* were collected from cattle shelter, 25.0%(6) from larval containers, 16.7% (4) from grain storages and 12.5% (3) indoors. In addition, most of the blood fed *Aedes* species were collected from the cattle shelters (Fig 3 & S2 Table).

Discussion

In the Metema District of Northwestern Ethiopia, *Ae. aegypti* was the most prevalent species among *Aedes* mosquitoes followed by *Ae. vittatus*, *Ae. communis*, *Ae. albopictus* and *Ae. opok*. This entails that the district is at high risk of *Aedes*-transmitted viral diseases. *Ae. aegypti, Ae. albopictus* and *Aedes vittatus* have been reported as the vector of viral diseases such as Zik virus fever, yellow fever, dengue fever and chikungunya fever outbreaks [36], invention of different arbovirus diseases to the community through biting *Aedes* species [37], currently, Aedes mosquitoes expansion from low to highland driving environmental factors [38]. It is thus imperative to characterize *Aedes* mosquitoes for their infection with viral pathogens of public health importance.

The highest numbers of *Ae. aegypti*, *Ae. vittatus*, *Ae. communis*, *Ae. albopictus* and *Ae. opok* were collected from outdoors during 6:00am-7:00am more specifically in cattle shelters followed by local grain storages. This reveals that the available five *Aedes* species, in Metema District, exhibit outdoor

resting behaviors. Similar behavior was reported from the Southern Afar [39, 40]. This can result from their behavioral resistance to insecticides used in indoor residual insecticide spraying and long-lasting insecticide treated nets-based interventions both of which are applied indoors. On the other hand, they could adapt to both outdoor (preferably) and indoor resting sites. The high abundance of *Aedes* species in cattle shelters could be due to factors such as comparatively long-time stay of cattle as blood meal source, body heat and carbondioxide release by cattle.

Highest house indices and numbers of *Ae. aegypti*, *Ae. vittatus*, *Ae. communis*, *Ae. albopicus* and *Ae. opok* were documented during June-September 2023, relatively lower during May and October, 2023 and lowest during the months of November-April 2023. The high number of adult mosquitoes during the main rainy season corresponded to high average humidity, high rainfall and optimum temperature values. Similar observations were made in the southern Afar part of Ethiopia [41] observed *Ae. aegypti* found at declared tyres, *Ae. simpsoni* complex in Southwest Ethiopia [42], *Ae. simpsoni* and *Ae. africanus* in the Omo and Didessa river valleys [43], high number of *Ae. aegypti observed* in Dire Dawa [42] and Ae. aegypti and *Ae. hirsutus* in Somalia region of the country [23].

The great majority of the *Aedes* mosquitos were collected from outdoors and most of the outdoor collections were unfed. This is in agreement with the report from southern Senegal where high rates of unfed *Ae. aegypti* were observed outdoors than indoors [44]. However, our result was different from the report by [45] in northern Thailand where the *Ae. aegypti* were collected abundantly (96.6%) at intermediate and lower heights in bed rooms or bathrooms. In Panama City, Ae. aegypti were observed resting indoors, living rooms and bathrooms [46] The differences in these resting behaviors could emanate from differences in the presence of adequate humidity.

Highest numbers of blood fed *Ae. aeygpti* and *Ae. vitatus* were collected from cattle shelters followed by grain storage and indoors due to genetical factors and suitable environmental conditions such as attractant clue of carbon dioxide emitted from domestic animals, body heat and other mammalian olfaction and local grain storage place has shadow and avoidance of rains. Basic feature of *Aedes* mosquitoes have repeated biting hosts until full fresh blood feds. It indicated that *Aedes* mosquito blood feeding habits play a key role of arboviral diseases transmission. In addition, blood feeding habits information can also improve disease management strategies, such as targeted vector control to reduce vector-host contact and contribute to forecasting future zoonotic disease risk in human and domestic animal populations

Arboviral diseases control strategies in Metema district can target outdoor resting habitats such as cattle shelters, grain storage, artificial water containers, deep grooves, and under bridges. Mosquito resting behavior changes with the season variation. Therefore to reduce the spread of viruses carried by *Aedes* speciece to develop targeted resting habitats in the seasonal variation. In the wet season, focused on cattle shelters and grain storage were applied sprayed resiudual insecticides and realsed reppelent chemicals or smook, community awarness and dicard contaners removed or recycled. Whereas, in ther dry season targeted to deep grooves and under bridge were applied to spray adulticidal

insecticides, clean herbs and shurbs under bridge and covered or fill deep droove. This seasonal targeting increases the effectiveness of vector control and helps reduce the risk of arboviral disease transmission

Limitations of the study

Thirteen adult mosquito species were identified based on their morphological characteristics using a stereomicroscope and standard morphological identification keys at the study sites. These species belonged to four genera. However, species-level confirmation using molecular techniques was not performed due to limitations in primers, master mix, and reagents, and also the blood-meal sources of *Aedes* mosquitoes were not determined molecularly. In addition, seasonal dominant species were not assessed across the three towns in the district.

Conclusion and recommendation

Aedes vector species transmit arboviral diseases worldwide. In the study site, the distribution, abundance, and species composition of *Aedes* vectors across seasons and months were clearly described. Five *Aedes* species were observed of which *Ae. aegypti* and *Ae. vittatus* were distributed to Metema-Yohannes, Kokit, and Gendawuha towns, and *Ae. communis* was found in the first two towns while *Ae. albopictus* and *Ae. opok* only in Metema-Yohannes town. High numbers of *Ae. aegypti* and *Ae. vittatus* were collected from cattle shelters, *Ae. communis* and *Ae. albopictus* from inside larvae containing man-made containers and *Ae. opok* inside a bridge. The large number of *Ae. aegypti* and *Ae. vittatus* species were collected in various resting places from June to September that indicated to potentially high risk of arbovirus transmission. This information is therefore critically important to develop appropriate vector control targeted to resting places according to seasonal variation and raising public health awareness about arboviral disease transmission.

Declarations

Author Contributions

WJ, AA, and SD made substantial contributions to conception and design, or analysis and interpretation of data. WJ made all the experiments and was a major contributor in writing the manuscript. WJ, AA, and SD been involved in drafting the manuscript or revising it critically for important intellectual content. All authors read and approved the final manuscript.

Funding

This study was financially supported by Addis Ababa University and University of Gondar, Ethiopia provided to covered field sample collection expense and protoparck aspirator, silica gel, zip plastic and compound microscope but not decision to publish, or preparation of the manuscript.

Availability of data and materials

All data generated or analyzed during this study are included in manuscript files and its supplementary information files.

Ethics approval and consent to participants

The study was ethically approved by the institutional review board (IRB) of Aklilu Lemma Institute of Pathobiology, Addis Ababa University, Ethiopia with the reference number ALIPB IRB/79/2014/22. Additionally, written permission letters were obtained from the Metema Woreda (district) health bureaus and health centers. Consent of human participant agreement was explained to the mosquito larvae/pupae surveys and adult *Aedes* mosquitoes were collected from selected households in the resting places.

Competing interests

The authors declare that they have no competing interests.

References

1. Nigatu W et al. *Aedes* Mosquitoes distribution and risk of Yellow Fever transmission in Gurage Zone, Southwest Ethiopia. Ethiopian Journal of Public Health and Nutrition (EJPHN), 2020. 4(1): pp. 21–31.
2. Mohamed MA, et al. Epidemiological investigation of dengue fever outbreak and its socioeconomic determinants in Banadir region, Somalia. BMC Infect Dis. 2024;24(1):393.
3. Halstead S, Wilder-Smith A. Severe dengue in travellers: pathogenesis, risk and clinical management. J Travel Med. 2019;26(7):taz062.
4. Marcos-Marcos J, et al. Impact, economic evaluation, and sustainability of integrated vector management in urban settings to prevent vector-borne diseases: a scoping review. Infect Dis poverty. 2018;7:1–14.
5. Wilder-Smith A, et al. Epidemic arboviral diseases: priorities for research and public health. Lancet Infect Dis. 2017;17(3):e101–6.
6. Robert MA, Stewart-Ibarra AM, Estallo EL. Climate change and viral emergence: evidence from *Aedes*-borne arboviruses. Curr Opin Virol. 2020;40:41–7.
7. Ajlan BA, et al. Assessment of the new World Health Organization's dengue classification for predicting severity of illness and level of healthcare required. PLoS Negl Trop Dis. 2019;13(8):e0007144.
8. Renard A, et al. Interaction of Human Behavioral Factors Shapes the Transmission of Arboviruses by Aedes and Culex Mosquitoes. Pathogens. 2023;12(12):1421.
9. van Den Berg H, Velayudhan R, Yadav RS. Management of insecticides for use in disease vector control: Lessons from six countries in Asia and the Middle East. PLoS Negl Trop Dis. 2021;15(4):e0009358.

10. Ahmed YM, Salah AA. Epidemiology of dengue fever in Ethiopian Somali region: retrospective health facility based study. Cent Afr J Public Health. 2016;2(2):51–6.
11. Ferede G, et al. A serologic study of dengue in northwest Ethiopia: Suggesting preventive and control measures. PLoS Negl Trop Dis. 2018;12(5):e0006430.
12. Degife LH, et al. Factors associated with dengue fever outbreak in Dire Dawa administration city, October, 2015, Ethiopia-case control study. BMC Public Health. 2019;19:1–7.
13. Geleta EN. Serological evidence of dengue fever and its associated factors in health facilities in the Borena Zone, South Ethiopia. Research and reports in tropical medicine, 2019: pp. 129–136.
14. Burkett-Cadena ND, Eubanks MD, Unnasch TR. Preference of female mosquitoes for natural and artificial resting sites. J Am Mosq Control Assoc. 2008;24(2):228.
15. Lilay A, et al. Reemergence of yellow fever in Ethiopia after 50 years, 2013: epidemiological and entomological investigations. BMC Infect Dis. 2017;17:1–6.
16. Tufa YA, et al. Qualitative research on yellow fever outbreak responses in Wolaita zone of SNNPR region, Ethiopia. Am J Health Res. 2020;8(3):32–41.
17. Shimelis T, et al. Detection of dengue virus infection in children presenting with fever in Hawassa, southern Ethiopia. Sci Rep. 2023;13(1):7997.
18. Mesfin Z et al. Dengue Fever Outbreak Investigation in Werder Town, Dollo Zone, Somali Region, Ethiopia. Infection and Drug Resistance, 2022: pp. 7207–7217.
19. Geleta D, et al. Epidemiological description of chikungunya virus outbreak in Dire Dawa Administrative City, western Ethiopia, 2019. Int J Clin Exp Med Sci. 2020;6(3):41.
20. Asebe G, et al. Seroprevalence of Yellow fever, Chikungunya, and Zika virus at a community level in the Gambella Region, South West Ethiopia. PLoS ONE. 2021;16(7):e0253953.
21. Mohamed N, et al. Prevalence and identification of arthropod-transmitted viruses in Kassala state, Eastern Sudan. Libyan J Med. 2019;14(1):1564511.
22. Ferede G, et al. Evidence of chikungunya virus infection among febrile patients in northwest Ethiopia. Int J Infect Dis. 2021;104:183–8.
23. Yared S, et al. Breeding habitats, bionomics and phylogenetic analysis of Aedes aegypti and first detection of Culiseta longiareolata, and *Ae. hirsutus* in Somali Region, eastern Ethiopia. PLoS ONE. 2024;19(1):e0296406.
24. Ortega-López LD, et al. Behaviour and distribution of *Aedes aegypti* mosquitoes and their relation to dengue incidence in two transmission hotspots in coastal Ecuador. PLoS Negl Trop Dis. 2024;18(4):e0010932.
25. Sauer F, et al. Habitat and microclimate affect the resting site selection of mosquitoes. Med Vet Entomol. 2021;35(3):379–88.
26. Mohammed bk. distribution of banana (musaspp.) fusarium wilt (fusarium oxysporum f. sp. cubense) and evaluation of cultivars against the disease in gamo zone, southern ethiopia. 2023, haramaya university.

27. Getachew Ferede GF et al. Distribution and larval breeding habitats of *Aedes* mosquito species in residential areas of northwest Ethiopia. 2018.
28. Jemberie W, Dugassa S, Animut A. Physical and chemical characteristics of Aedes larval habitats in Metema District, Northwest, Ethiopia. BMC Ecology and Evolution, 2025. 25: p. 59.
29. Jemberie W, Dugassa S, Animut A. Biting Hour and Host Seeking Behavior of *Aedes* Species in Urban Settings, Metema District, Northwest Ethiopia. Trop Med Infect Disease. 2025;10(2):38.
30. Organization WH. Pictorial identification key of important disease vectors in the WHO South-East Asia Region. 2020.
31. Bigot J. Trois diptères nouveaux de la Corse. in Annales de la Société entomologique de France. 1861.
32. Huang Y-M. Notes on the Taxonomic Status of *Aedes Vittatus*. Diptera, Culicidae). American Entomological Institute; 1977.
33. Ngingo BL, et al. *Aedes aegypti* abundance, larval indices and risk for dengue virus transmission in Kinondoni district, Tanzania. Trop Med Health. 2022;50(1):1.
34. Krebs CJ. Ecology. The experimental analysis of distribution and abundance. 1972.
35. Lande R. Statistics and partitioning of species diversity, and similarity among multiple communities. Oikos, 1996: pp. 5–13.
36. Powell JR. Mosquito-borne human viral diseases: why *Aedes aegypt*i? The American journal of tropical medicine and hygiene, 2018. 98(6): p. 1563.
37. Little EA, et al. Host interactions of *Aedes albopictus*, an invasive vector of arboviruses, in Virginia, USA. PLoS Negl Trop Dis. 2021;15(2):e0009173.
38. Babalola AS, et al. Geospatial modeling of geographical spread of *Aedes* species, in relation to climatic and topographical factors in Lagos State, Nigeria. PLoS Negl Trop Dis. 2025;19(2):e0012860.
39. Badolo A, et al. First comprehensive analysis of *Aedes aegypti* bionomics during an arbovirus outbreak in west Africa: Dengue in Ouagadougou, Burkina Faso, 2016–2017. PLoS Negl Trop Dis. 2022;16(7):e0010059.
40. Seid M, et al. Resting habitat, blood meal source and viral infection rate of *Aedes aegypti* (Diptera: Culicidae) in the Southern Afar Region of Ethiopia. BMC Infect Dis. 2025;25(1):346.
41. Seid M, Aklilu E, Animut A. Spatio-temporal occurrence and habitat characteristics of Aedes aegypti (Diptera: Culicidae) larvae in Southern Afar region, Ethiopia. Trop Med Health. 2024;52(1):51.
42. Waldetensai A, Pareyn M, Massebo F. Human-biting activity, resting behavior and yellow fever virus transmission potential of aedes mosquitoes in southwest ethiopia. Parasitologia. 2023;3(1):87–100.
43. Neri P, Andral L, Poirier A. Studies on yellow fever in Ethiopia. 4. Entomological studies in the locality of Manera. Bull World Health Organ. 1968;38(6):863–72.

44. Diallo D, Diallo M. Resting behavior of *Aedes aegypti* in southeastern Senegal. Parasites Vectors. 2020;13(1):356.
45. Seang-Arwut C, et al. Indoor resting behavior of *Aedes aegypt*i (Diptera: Culicidae) in northeastern Thailand. Parasites Vectors. 2023;16(1):127.
46. Dzul-Manzanilla F, et al. Indoor resting behavior of *Aedes aegypti* (diptera: Culicidae) in Acapulco, Mexico. J Med Entomol. 2017;54(2):501–4.

Tables

Table Files

Table 1: Distribution of four genera mosquito species in Metema district, Northwest, Ethiopia

Study Site	Inspected house	Posetive house	*Anopheles* species (%)	Aedes species (%)	*Culeseta* species (%)	*Culex* species (%)
Metema Yohannes	327	103	*An. gambiae s.l.* =68	*Ae. aegypti* =1081	*Cs. Longiareolata* = 0	*Culex* spp. = 1922
			An. Stephensi =52	*Ae. vittatus* = 307		
			An. Pharensis =18	*Ae. communis* = 0		
			An. Pretoriensis =49	*Ae. albopictus* = 77		
			An. Christyi =30	*Ae. opok* = 42		
			An. Cinereus =32			
Total	327	103	6.7% = 249/3678	40.9% = 1507/3678	0.0% = 0/3678	52.2% = 1922/3678
Kokit	298	81	*An. gambiae s.l.* = 59	*Ae. aegypti* = 935	*Cs. Longiareolata* = 41	*Culex* spp. = 1507
			An. Stephensi = 38	*Ae. vittatus* = 243		
			An. Pharensis = 17	*Ae. communis* = 101		
			An. Pretoriensis = 46	*Ae. albopictus* = 0		
			An. Christyi = 24	*Ae. opok* = 0		
			An. Cinereus = 24			
Total	298	81	6.8% = 208/3035	42.1% = 1279/3035	1.3% = 41/3035	49.6% = 1507/3035
Genda Wuha	452	92	*An. gambiae s.l.* = 57	*Ae. aegypti* = 1010	*Cs. Longiareolata* = 115	*Culex* spp. = 1595
			An. Stephensi = 45	*Ae. vittatus* = 173		
			An. Pharensis =18	*Ae. communis* = 85		
			An. Pretoriensis = 49	*Ae. albopictus* = 0		
			An. Christyi = 30	*Ae. opok* = 0		
			An. Cinereus = 46			
Total	452	92	7.6% = 245/3223	39.3% = 1268/3223	3.5% = 115/3223	49.4% =1595/3223

Table 2: Adult *Aedes* mosquitoes collected from indoor resting places in three towns of Metema District, Northwestern, Ethiopia, January-December, 2023

		Indoor collection		
Species mosquitoes	Resting habitat	Mean ± SE	Resting Index (RI)	P -Value
Aedes aegypti	Main Room	33 ± 3.66	0.14	0.001
	Bed Room	49 ± 4.04	0.84	
	Kitchen Room	4 ± 0.88	0.02	
Aedes vittatus	Main Room	9 ± 4.50	*0.47*	0.025
	Bed Room	10 ± 2.09	*0.53*	
	Kitchen Room	0 ± 0.00	*0.0*	
Aedes communis	Main Room	6 ± 3.75	*0.79*	*0.206*
	Bed Room	1 ± 1.20	*0.21*	
	Kitchen Room	0 ± 0.00	*0.00*	
Aedes albopictus	Main Room	0 ± 0.00	*0.0*	*0.000*
	Bed Room	0 ± 0.00	*0.0*	
	Kitchen Room	0 ± 0.00	*0.0*	
Aedes opok	Main Room	0 ± 0.00	*0.0*	*0.000*
	Bed Room	0 ± 0.00	*0.0*	
	Kitchen Room	0 ± 0.00	*0.0*	

Table 3: Adult *Aedes* mosquitoes collected from outdoor resting places in three towns of Metema District, northwestern Ethiopia, January-December, 2023

		Outdoor collection		
Species mosquitoes	Resting habitat	Mean ± SE	Resting Index (RI)	P -Value
Aedes aegypti	Grain storage	170 ± 11.54	0.18	0.001
	Deep groove	63 ± 6.06	0.06	
	Cattle shelter	312 ± 6.92	0.33	
	Larvae container	291 ± 6.08	0.31	
	Under bridge	85 ± 5.05	0.09	
Aedes vittatus	Grain storage	52 ± 5.78	0.14	0.010
	Deep groove	11 ± 0.88	0.11	
	Cattle shelter	71 ± 14.46	0.31	
	Larvae container	69 ± 16.34	0.19	
	Under bridge	16 ± 13.15	0.45	
Aedes communis	Grain storage	11 ± 6.58	0.16	0.787
	Deep groove	8 ± 4.91	0.09	
	Cattle shelter	15 ± 10.72	0.31	
	Larvae container	14 ± 7.31	0.38	
	Under bridge	4 ± 2.6	0.04	
Aedes albopictus	Grain storage	2 ± 0.26	0.10	0.963
	Deep groove	6 ± 6.66	0.25	
	Cattle shelter	5 ± 5.66	0.02	
	Larvae container	7 ± 7.33	0.28	
	Under bridge	3 ± 3.33	0.01	
Aedes opok	Grain storage	0 ± 0.00	0.00	0.856
	Deep groove	3 ± 3.66	0.26	
	Cattle shelter	3 ± 3.00	0.22	
	Larvae container	2 ± 2.33	0.16	
	Under bridge	5 ± 5.00	0.35	

Table 4: Resting behavior of *Aedes* species in dry and wet season in Metema District, northwestern Ethiopia, January-December, 2023

	Wet season				
Aedes species	Resting habitat	Mean	Mean Rank	Mann Whitny U-test	P-vale
Aedes aegypti	Outdoor	2448	21.90	16.500	0.001
	Indoor	240	9.10		
Aedes vittatus	Outdoor	627	21.73	19.000	0.001
	Indoor	51	9.27		
Aedes communis	Outdoor	131	19.20	57.000	0.021
	Indoor	21	11.80		
Aedes albopictus	Outdoor	72	17.60	81.000	0.202
	Indoor	0	13.40		
Aedes opok	Outdoor	40	17.10	88.500	0.325
	Indoor	0	13.90		
	Dry season				
Aedes species	Resting habitat	Mean	Mean Rank	Mann Whitny U-test	P-vale
Aedes aegypti	Outdoor	316	22.50	7.500	0.001
	Indoor	22	8.50		
Aedes vittatus	Outdoor	39	21.70	19.500	0.001
	Indoor	6	9.30		
Aedes communis	Outdoor	31	18.57	81.500	0.201
	Indoor	3	13.43		
Aedes albopictus	Outdoor	5	17.13	83.000	0.323
	Indoor	0	13.87		
Aedes opok	Outdoor	2	16.63	80.500	0.187
	Indoor	0	12.37		

Figures



Figure 1

Resting adult Aedes mosquitoes collected from different resting habitats: a) Aedes mosquitoes collected from deep groove resting habitats. b) Aedes mosquito were collected from indoor and outdoor resting places.

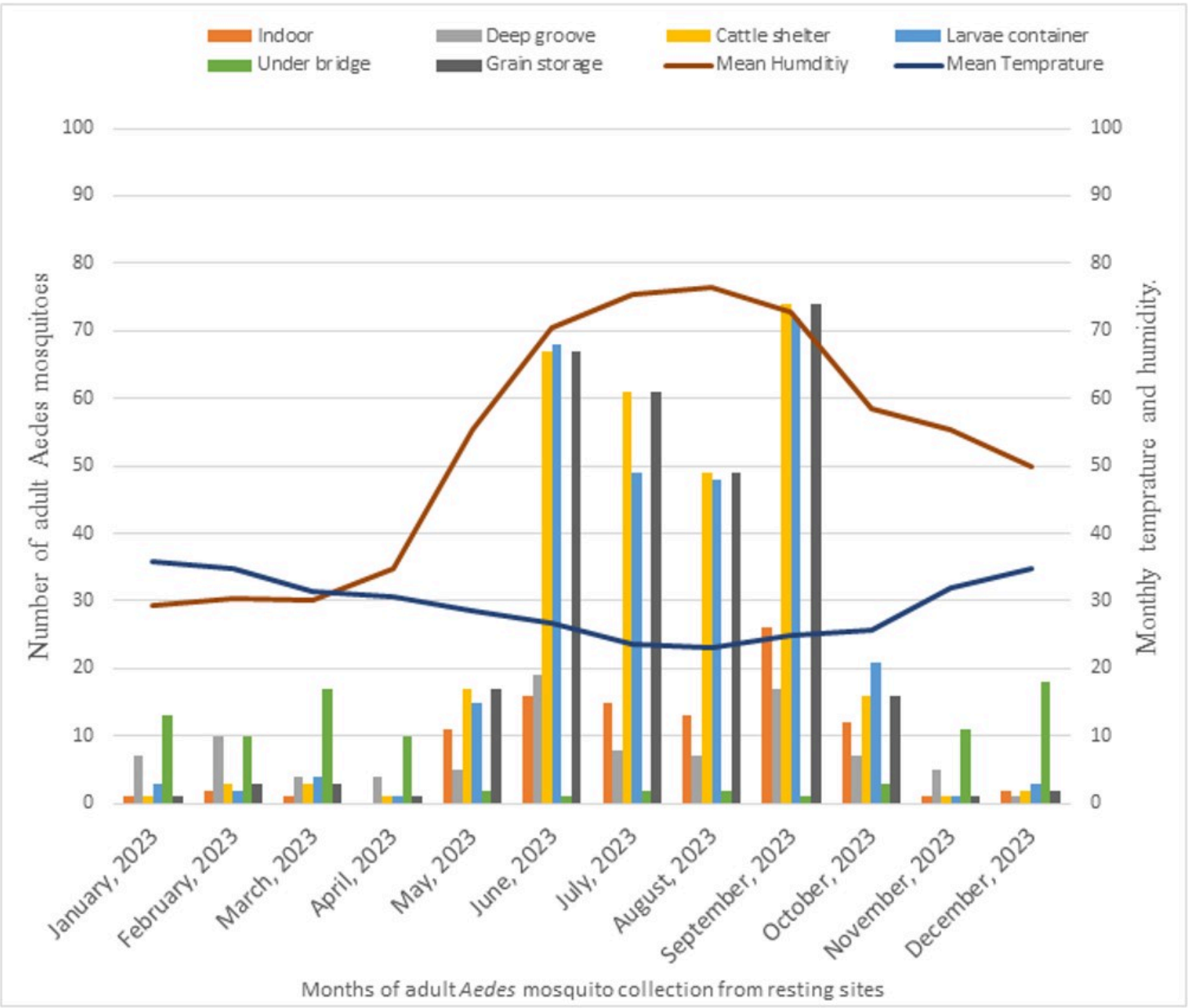


Figure 2

Monthly distribution of adult *Aedes* mosquitoes in the different resting places, Metema District, January-December, 2023

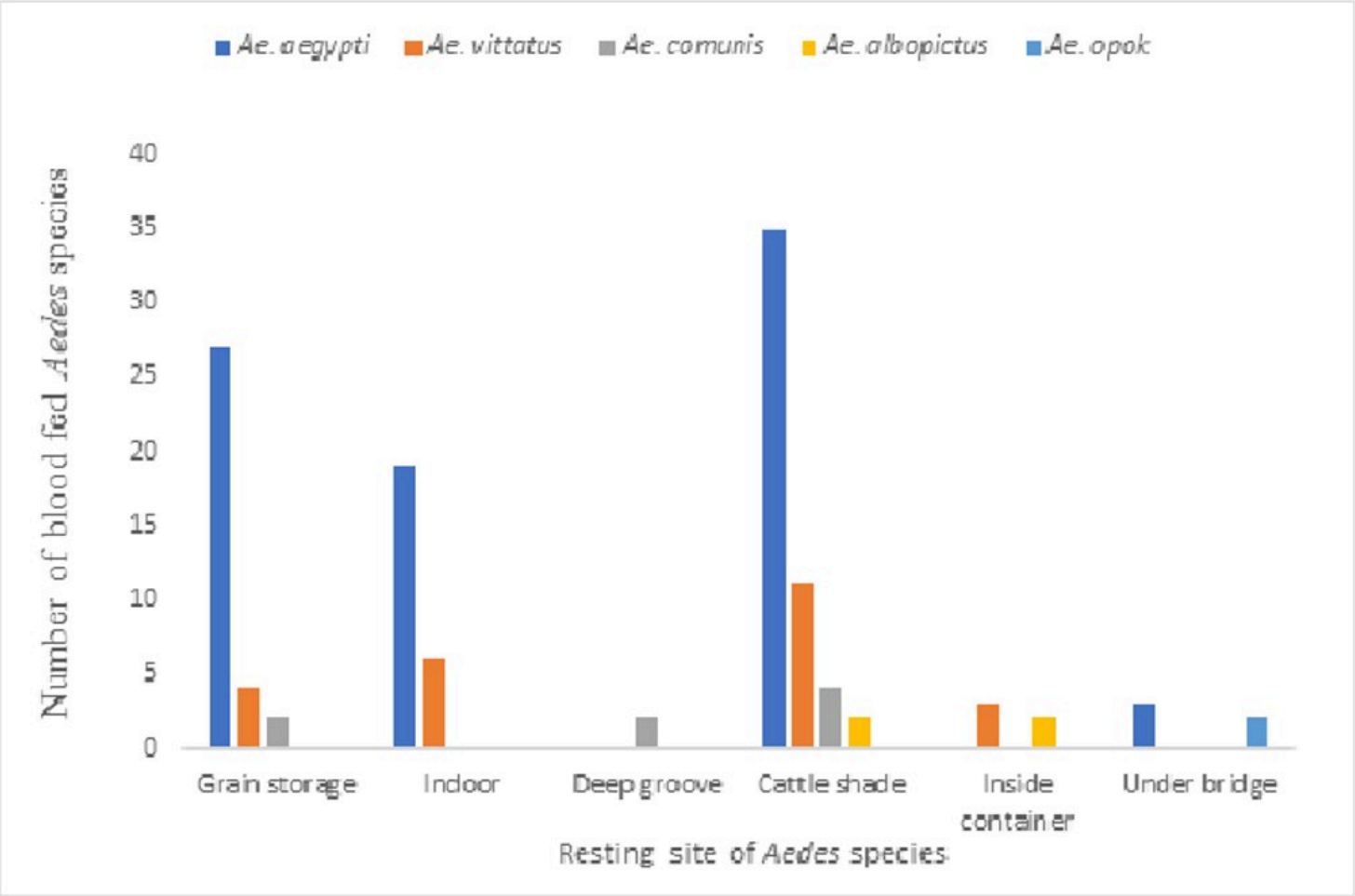


Figure 3

Abdominal status of *Aedes*species collected from different resting sites in Metema District, northwestern Ethiopia, January - December 2023

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryinformationfiles.docx