Available on: https://jnsrr.ep-journals.org/ E-ISSN: 3051-3766 P-ISSN: 3051-3758

Journal of Natural Science Research and Review

Volume: 01 Issue: 05 November-2025

The Effectiveness of Mosquito Traps During the Peak of Dry Season Across Four Local Government Areas in Ondo State, Nigeria

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Published Date: November 03, 2025 **Article DOI: 10.65150/EP-jnsrr/V1E5/2025-02**

ABSTRACT: Mosquito vector control is considered the most effective way to prevent the spread of vector-borne diseases, as vaccines and/or efficient treatments are not always available. The study was carried out in four Local Government Areas of Ondo State comprising Ondo West, Akure South, Owo, and Akoko South West for the period of four months. The study was conducted on a 24-hour basis (12 hrs morning and 12 hrs night). The implantation was done involving analyzing the environment to determine the appropriate locations to set up the traps. The BG and BG-PRO (light disconnected) were set up in the morning between 6:00 am and 6:00 pm, while the BG-PRO (light connected) and CDC light traps were set up between 6:00 pm and 6:00 am. Attractants (lures) were also used with the BG and BG-PRO. The result of the study revealed that CDC light traps had the highest mosquito catch in January (16) and 32 in February (32). It was also revealed that in March, BG had the highest catches of mosquitoes (55), while the CDC light traps had the least mosquito catch (29). The highest number of mosquitoes caught in April across the four LGAs was done by the CDC light traps (52), while the BG-PRO had no catch throughout the month. The result also revealed that in January, both Ondo West and Akure South had an equal number of mosquitoes caught by the traps (12), while Owo and Akoko South-West recorded no catch. Akure South recorded the highest number of mosquitoes in February (27) while in March, Owo recorded the highest mosquito catch (49). In April, Ondo West recorded the highest mosquito catch (22) and Owo had the least catch (14). These findings emphasize the importance of the selection of trap types based on seasonal vector behaviour and environmental conditions so that vector control programmes can work better and the risk of mosquito-borne diseases can be minimized.

KEYWORDS: Mosquito, Vector Control, Mosquito Traps, LGAs, Ondo State.

INTRODUCTION

Mosquitoes are a group of thousands of species of small insects that are flies (Order Diptera) and constitute the family Culicidae (Foster and Walker, 2019). Various species of mosquitoes are found all over Nigeria and are not restricted by changes in topography across the country (Omar *et al*., 2021). 3,500 species of mosquitoes grouped into 41 genera have been identified, and many are vectors of diseases such as malaria, Yellow Fever, Chikungunya, West Nile, Dengue Fever, Filariasis, Zika virus and other Arboviruses (Adeyekun, 2021). By transmitting diseases, mosquitoes cause the deaths of over 700,000 people each year (Ferraguti *et al*., 2021).

Mosquito vector control is considered the most effective way to prevent the spread of vector-borne diseases, as vaccines and/or efficient treatments are not always available (Wilson *et al*., 2020; Paradkar *et al*., 2021). Several strategies have been implemented to control mosquitoes and their role as vectors, including chemical, biological, physical, and integrated control methods (Bouzid *et al.*, 2016). Overall, utilizing a combination of control measures known as integrated vector management has turned out to be a powerful method for managing and reducing the spread of diseases transmitted by mosquitoes (Nash *et al.*, 2021). The chemical approach involves the application of insecticides, either targeting adult mosquitoes or their larvae (Hemingway, 2018). Since the introduction of dichlorodiphenyltrichloroethane (DDT) in the 1940s, various products have been

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used to control mosquitoes and their ability to transmit diseases, making this chemical an effective primary intervention (Chrustek *et al.*, 2018). Unfortunately, this method has several limits and inconveniences, including affecting a wide range of insects, the development of resistance genes, and significant toxicity to animals and humans (Richardson *et al*., 2019). Insecticides, including pyrethroids, which are commonly used to control mosquitoes, have been found to have various negative effects on human health (Brühl *et al*., 2020).

Recently, integrated vector management programs have increasingly been incorporating the use of Sterile Insect Technique (SIT) in mosquito control efforts. This method incurs significant expenses due to the costs associated with producing, sterilizing, and releasing the sterile insects (Oliva *et al*., 2021). As an environmentally friendly alternative, physical methods of controlling mosquitoes may be promising strategies. This involves suppressing insects through physical or mechanical means (Liu *et al*., 2022). Physical measures, including traps such as BGS (Biogents Sentinel), light traps, mosquito magnets, and various trapping strategies for adult mosquito removal, are commonly used in surveillance and integrated mosquito control programs (Akhoundi *et al*., 2018). Trap design (e.g., counterflow, downdraft), placement (e.g., height above ground, time of day), location (local environment, habitat specificity of mosquito), and use of attractants (e.g., light, CO_2, octenol) influence mosquito abundance estimates and also affect the species, number, and reproductive status (parity) of mosquitoes captured (Poulin *et al.*, 2017). Knowledge of trap biases is essential when deciding what traps to use, where they are to be deployed, and how to interpret the results. Recognition of these biases is especially important when modelling mosquito species distributions and designing mosquito-borne disease surveillance programs (Mancini *et al*., 2017). This study aims to investigate the effectiveness of mosquito traps in reducing the abundance of adult mosquitoes and to evaluate the mosquito species diversity in the four Local Government Areas of Ondo State during the peak of the dry season.

MATERIALS AND METHODS

Study Area

The study was carried out in four Local Government Areas of Ondo State comprising of Ondo West, Akure South, Owo and Akoko South West (Fig. 1). Ondo State is situated in the south-western part of Nigeria with geographical coordinates of 5° 45 ' N, 4° 20' E, and 7° 52' N, 6° 05' E. The state lies in a tropical rainforest biome with excellent vegetation that spawns almost all year round, indicative of a good breeding environment for all sorts of fauna and flora. These LGAs exhibit a mix of urban and semi-urban settlements, with agriculture serving as a major economic activity alongside growing involvement in commerce and civil service due to increasing urbanization. They also experience similar climatic conditions characterized by a

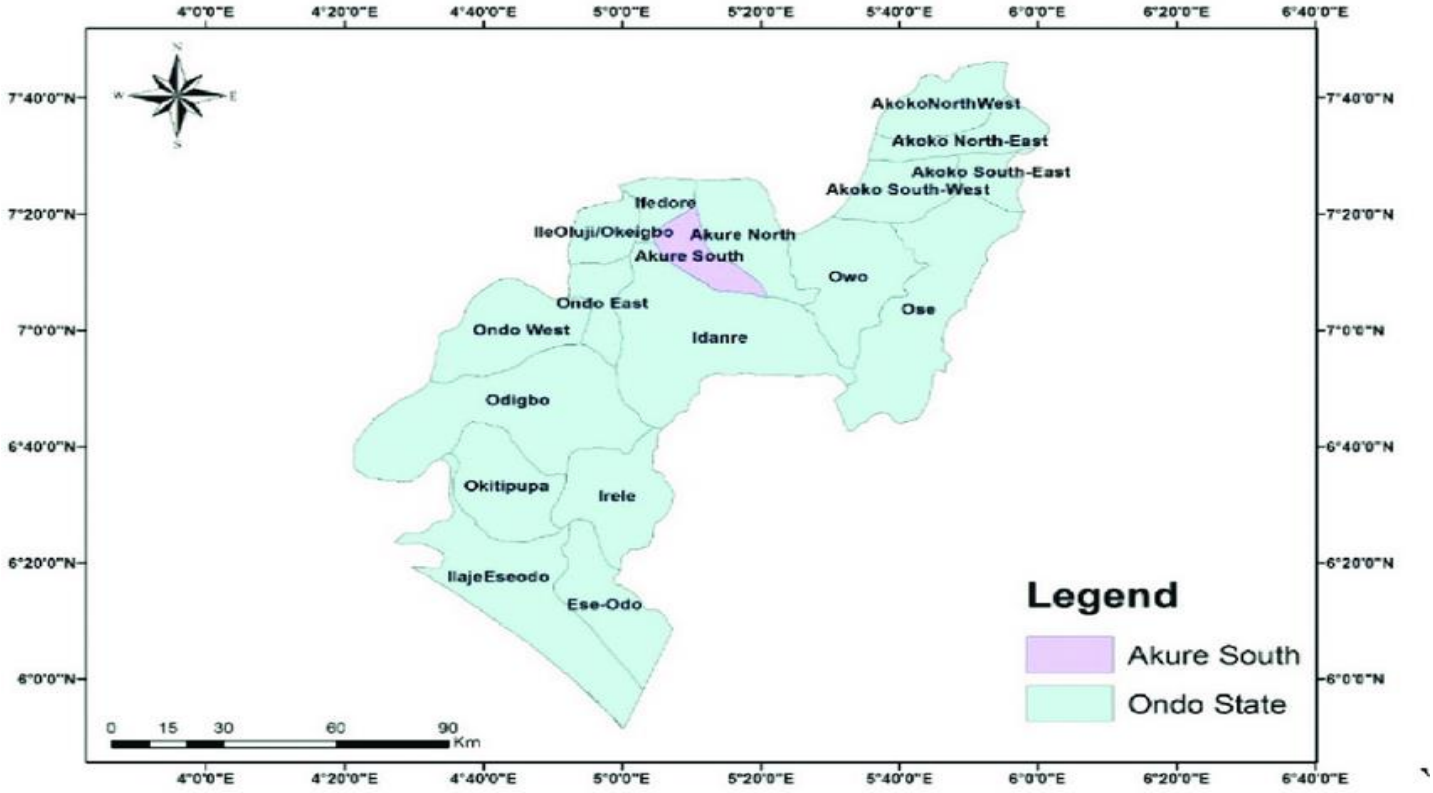


Fig. 1: Map of Ondo State Showing the Four LGAs.
Source: Alabi (2021).

tropical wet and dry climate, which influences local farming patterns and public health challenges such as seasonal disease outbreaks. All the four LGAs host various educational institutions and health facilities, contributing to regional development and access to social services, though infrastructural gaps remain a shared concern.

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Ethical Statement

The study was conducted in an area where mosquito-borne diseases had been reported. An advocacy visit was paid to the owners of the houses of each site in the LGAs to seek the consent and approval to carry out the surveillance (setting the mosquito traps).

The Mosquito Traps

Biogents (BG) Second Generation Traps: The Biogents (BG) Second Generation Traps (Plate 1), developed in line with World Health Organization (WHO) standards, are advanced mosquito surveillance tools specifically designed for the effective capture of *Aedes* species, particularly *Aedes aegypti* and *Aedes albopictus*, which are primary vectors of dengue, Zika, and chikungunya viruses. These traps use a combination of visual cues, convection currents, and chemical lures such as the BG-Sweetscent to mimic human odour, thereby attracting female mosquitoes seeking a host. The second-generation BG traps have improved durability, user-friendly features, and enhanced catch rates compared to earlier models, making them highly suitable for both research and operational vector control programs.

Biogents (BG-PRO) Third Generation Traps: The Biogents (BG PRO) third-generation trap (Plate 2) represents Biogents' latest professional-grade system, designed to consolidate the functions of CDC-style, EVS-style, and BG-Sentinel traps into a single, modular platform that meets WHO-endorsed surveillance standards. According to Biogents, the BG-PRO matches or exceeds the performance of both the BG-Sentinel and CDC traps in capturing *Aedes aegypti*, *Aedes albopictus*, and *Culex quinquefasciatus*, and supports optional CO_2 augmentation typically increasing catch rates of *Ae. albopictus* and *Cx. quinquefasciatus* by approximately five-fold—for broader species coverage. Ready-to-use in a standard kit, the BG-PRO includes catch bags, funnel net, tripod, LED light, and a dry-ice carry bag making it a highly versatile tool for both operational vector control and entomological surveillance under environmental conditions typical of WHO-aligned IVM programs.

CDC Light Traps: The CDC miniature light trap (Plate 3), originally developed in the 1960s by the US Centers for Disease Control (CDC), is a lightweight and portable tool widely recommended for adult mosquito surveillance and endorsed by WHO-affiliated expert networks. It operates with a small light source combined with a suction fan powered by a 6 V battery, drawing mosquitoes into a collection cup via a downward airflow. Standard operational guidance recommends placing traps approximately 5–6 ft above ground, ideally along habitat edges, and leaving them deployed from dusk until dawn to effectively sample nocturnal species such as *Anopheles*, *Culex*, and *Aedes*.

METHODS

The study was conducted for four months (January to April) and usually occurred within three (3) days in each month. A total of 4 traps (1 BG, 1 BG-PRO, and 2 CDC light traps) were set up in each LGA. The study was conducted on a 24-hour basis (12 hrs morning and 12 hrs night). The implantation was done involving analyzing the environment to determine the appropriate locations to set up the traps. The BG and BG-PRO (light disconnected) were set up in the morning between 6:00 am and 6:00 pm, while the BG-PRO (light connected) and CDC light traps were set up between 6:00 pm and 6:00 am. Attractants (lures) were also used



Plate 1: BG



Plate 2: BG-PRO

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Plate 3: CDC Light Trap

with the BG and BG-PRO. Mosquitoes captured within a 24-hour period were of excellent preservation quality, allowing easy morphological identification. Once in the laboratory, all mosquitoes captured by the traps were individually identified at the species level using the identification keys (Gillet, 1972; Gillies and Coetzee, 1987; WHO, 2013). If the mosquitoes were still alive, they were put into a freezer for 3–5 min. Once frozen, the mosquitoes were placed in a Petri dish before being identified.

Data Analysis

All the data collected were counted for each LGA and a pie chart was used to show the effectiveness of the traps.

RESULTS

Table 1-4 showed the effectiveness of the mosquito traps based on the number of mosquitoes caught in January, February, March, and April across the four LGAs. In Table 1, it was revealed that the total mosquitoes caught across the four LGAs by BG was 4, and BG-PRO was 4, while CDC light traps had the highest catch of 16 in January. In February (Table 2), the total mosquitoes caught by BG was 5; BG-PRO was 8, and CDC light traps caught 32 mosquitoes. In March (Table 3), it was revealed that BG has the highest mosquito catches (55), followed by BG-PRO (52), while CDC light had the least mosquito catches (29). In table 4, it was revealed that the highest catch of mosquitoes was done by CDC light traps (59), followed by BG (12), while BG-PRO had no catch throughout the month of April across the four LGAs. The result also revealed that in January, both Ondo West and Akure South had an equal number

of mosquitoes caught by the traps (12), while Owo and Akoko South-West recorded no catch. Akure South recorded the highest number of mosquitoes in February (27); Ondo West recorded 18 mosquitoes, while both Owo and Akoko South West recorded no mosquitoes. Owo recorded the highest mosquito catch in March (49), followed by Akure South (45) and Akoko South West (22), and Ondo West had the least mosquitoes recorded (20). In April, Ondo West recorded the highest mosquito catch (22), followed by Akure South (18), Akoko South West (17), and Owo (14). Fig. 2 revealed the CDC light traps were the most effective of the mosquito traps based on the total number of mosquitoes caught from January to April across the four LGAs.

DISCUSSION

The present study investigated the comparative effectiveness of three mosquito traps: the BG, BG-PRO, and CDC light traps across four Local Government Areas in Ondo State (Ondo West, Akure South, Owo, and Akoko South West) for a period of four months. The results exhibited marked variation in the effectiveness of the traps during different months and locations, demonstrating the combined effect of seasonal changes, trap technology, and environmental factors on the performance of mosquito traps. In January, the CDC light trap outperformed both BG and BG-PRO traps, catching 16 mosquitoes, while both variants of the BG traps recorded only 4 each. This observation aligns with Silver (2008) conclusion that CDC light traps are most efficient for detecting mosquito activity in the early dry season, taking into account their light-based attraction mechanism. Similarly, Ndung'u (2014) corroborated the effective use of CDC traps to capture diverse mosquito species, particularly during months of low density when phototactic species dominate. The mosquitoes caught in February greatly increased, particularly with the CDC light traps catching 32, whereas BG-PRO had 8, and BG 5. This result supports studies done by Degener *et al*. (2021) and Hribar *et al.* (2022) which

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Table 1: Show the Effectiveness of the Mosquito Traps Based on the Number of Mosquitoes Caught in January

TRAPS	ONDO WEST	AKURE SOUTH	OWO	AKOKO SOUTH WEST	TOTAL
BG	3	2	0	0	5
BG PRO	6	2	0	0	8
CDC LIGHT	9	23	0	0	32

Table 2: Show the Effectiveness of the Mosquito Traps Based on the Number of Mosquitoes Caught in February

TRAPS	ONDO WEST	AKURE SOUTH	OWO	AKOKO SOUTH WEST	TOTAL
BG	3	1	0	0	4
BG PRO	4	0	0	0	4
CDC LIGHT	5	11	0	0	16

Table 3: Show the Effectiveness of the Mosquito Traps Based on the Number of Mosquitoes Caught in March

TRAPS	ONDO WEST	AKURE SOUTH	OWO	AKOKO SOUTH WEST	TOTAL
BG	3	20	22	10	55
BG PRO	11	15	17	9	52
CDC LIGHT	6	10	10	3	29

Table 4: Show the Effectiveness of the Mosquito Traps Based on the Number of Mosquitoes Caught in April

TRAPS	ONDO WEST	AKURE SOUTH	OWO	AKOKO SOUTH WEST	TOTAL
BG	6	0	0	6	12
BG PRO	0	0	0	0	0
CDC LIGHT	16	18	14	11	59

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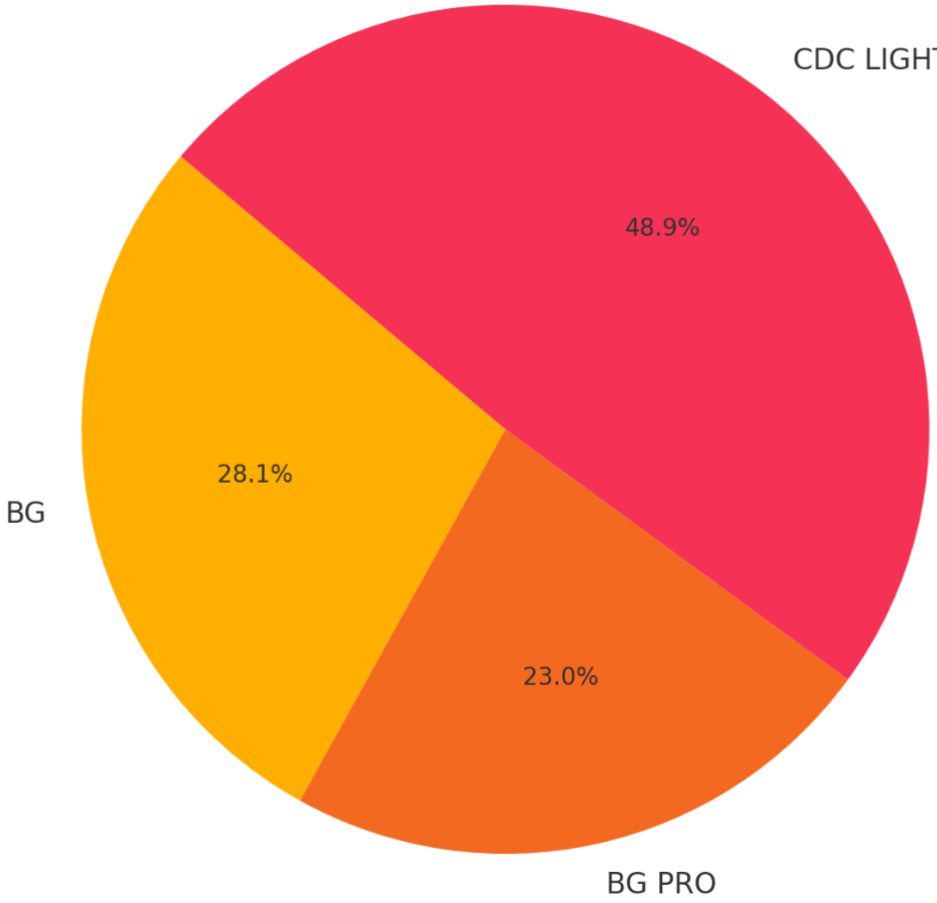


Fig. 2: Pie Chart Showing the Relative Effectiveness of BG, BG PRO, and CDC Light traps (Jan. to April) Across the Four LGAs.

observed a rise in mosquito activity from late dry to early wet seasons, and generally documented better using CDC light traps. This also goes in line with the findings of Afolabi *et al*. (2020) who observed that urbanized zones typically show higher vector densities due to anthropogenic impacts.

Yet, in March, an unprecedented turnaround occurred in the performance of BG and BG-PRO traps, nevertheless, bypassed CDC light traps. The counts included 55 for BG and 52 for BG-PRO, while only 29 were observed for CDC light traps. This observation may be linked to the increased number of host-seeking species of mosquitoes, in particular *Aedes* species, which tend to respond more to olfactory clues than light itself, according to the reports provided by Maciel-de-Freitas *et al*. (2006). BG traps, emulating host scent cues through the use of lures and CO_2, become very attractive during peak hours of host seeking by *Aedes*. The effectiveness

of these traps during peak breeding periods for *Aedes aegypti* and *Aedes albopictus* has been comprehensively established through the findings of Farajollahi *et al*. (2009). The result of April showed that CDC light traps made a strong comeback with 59 catches, followed by BG with 12 catches, while BG-PRO had no catches. The lack of catches in the BG-PRO trap could have several explanations, including malfunctioning of the trap, interference from environmental factors, or a possible behavioural avoidance from the target mosquito species (Degener *et al*., 2021). These findings corroborate with Wilke *et al*. (2019), who suggested that while BG traps may work during certain seasons, their efficiency is highly variable depending upon species dominance and temperate conditions. Strong sustained performance by the CDC light traps over several months tends to confirm their reliability as vectors surveillance tools, especially for nocturnal species such as *Anopheles* and *Culex*, as reported by Degefa *et al*. (2020).

The analysis of the spatial variation in mosquito trap performance across the LGAs gives our understanding of vector ecology a further boost. Akure South and Ondo West both recorded 12 mosquitoes each in January, suggesting that urban and peri-urban environments might have comparable breeding potentials at this time of the year. This was opposite in Owo and Akoko South West, which recorded no mosquitoes caught, presumably because of limited vector activity due to fewer breeding sites. These observations correlate with Ughasi *et al*. (2012), who reported seasonal dormancy of mosquito populations in certain ecological zones of Ghana. February results showed Akure South as the dominant LGA, with the highest mosquito count (27), further supporting the supposition that urbanization and inadequate drainage significantly enhance mosquito proliferation. Eze *et al*. (2016) reported similar findings in their study of mosquito distribution in Southeastern Nigeria, which consistently revealed higher trap yields in densely populated centers. In contrast, rural LGAs like Owo and Akoko South West continued to show zero catches, reflecting environmental heterogeneity across the state.

The result of March signified massive increases in mosquito populations for all the LGAs. Owo had the highest number of catches (49), which suggests a rapid burst in breeding activity proximately caused by changes in the environment before rains. This was supported by Fillinger *et al.*

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(2009), as upon onset of the rains, mosquito larvae quickly proliferate in stagnant water bodies that are constituents of agricultural zones. There were also high catches at Akure South and Akoko South West (45 and 22 respectively), suggesting a general increase in vector populations in support of the early seasonal importance of vector monitoring among rural-agricultural communities. The trend noted in April suggests an increase on the part of mosquitoes toward an even distribution across all LGAs. The highest number of mosquitoes recorded was Ondo West (22), Akure South (18), Akoko South West (17), and Owo (14). The apparent convergence in trap yields indicates that the appropriate breeding conditions were already well established across the region, probably as a result of increased humidity and rainfall. Ngami *et al*. (2017) and Oduola *et al*. (2012) have shown that the rainfall after the dry season engenders an upsurge in mosquito breeding over a number of ecozones, resulting in an almost equal distribution of vectors in both urban and rural settings.

CONCLUSION

The comparative analysis of mosquito traps across four LGAs over a four-month period revealed that CDC light traps emerged as the best trap for successful capture of mosquitoes, especially during the early and late months of the study. Even though the BG and BG-PRO traps were more effective during March, probably as a result of a heightened host-seeking activity of *Aedes* species, the CDC light trap continued to maintain its superiority in the long run and is thus a reliable tool for long-term mosquito surveillance. These findings emphasize the importance of the selection of trap types based on seasonal vector behaviour and environmental conditions so that vector control programmes can work better and the risk of mosquito-borne diseases can be minimized.

Ethics approval and consent to participate: No conflicting ethics
Consent for publication: All authors consented
Availability of data and material: Available on request
Competing interests: No conflicting interest

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