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Malaria Transmitting Anophiline Mosquito Larva in Fishponds of Mongu District, Western Province of Zambia

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ABSTRACT

Mongu District, situated in the malaria-endemic Western Province of Zambia, has witnessed a significant increase in fish farming activities in recent years. These practices have brought substantial economic and nutritional benefits to the local population, offering an alternative source of income and food security. However, poorly managed fishponds have emerged as potential breeding grounds for Anopheles mosquitoes, the primary vectors responsible for malaria transmission. This poses a dual challenge of promoting sustainable aquaculture while mitigating associated public health risks.

This study aimed to investigate whether mosquito larvae found in fishponds within Mongu District belonged to malaria-transmitting Anopheline species. A total of 26 fishponds were surveyed across the district, with larvae samples collected, preserved, and subjected to detailed morphological identification at the Macha Research Trust. The findings revealed the presence of Anopheline mosquito larvae, which have the potential to mature into adult vectors of malaria. Crucially, unlined fishponds were identified as hotspots for mosquito breeding, whereas lined ponds were completely devoid of larvae. These observations underscore the role of proper fishpond design and management in reducing mosquito proliferation. The study further highlights the effectiveness of lined ponds, which not only enhance water retention and fish productivity but also serve as a barrier against mosquito breeding. Additionally, the introduction of larvivorous fish species—fish that feed on mosquito larvae—was identified as a sustainable biological control measure to reduce malaria transmission risks associated with aquaculture.

These findings underscore the urgent need for integrated strategies that balance the economic benefits of fish farming with the imperative of malaria control. Recommendations include promoting the adoption of lined fishponds, training local farmers in best aquaculture practices, and encouraging the use of biological mosquito control methods such as larvivorous fish. Policymakers, public health officials, and aquaculture stakeholders must collaborate to ensure that fish farming contributes positively to livelihoods without exacerbating public health challenges.

This study serves as a critical reminder that the intersection of aquaculture and public health requires a coordinated approach to ensure sustainable development in malaria-endemic regions like Mongu District.

KEYWORDS: *Malaria, Anopheline, Mosquito Larvae, Fishponds, Mongu, Western Zambia*

INTRODUCTION

Malaria continues to be one of the most pressing global health challenges, particularly in sub-Saharan Africa, which accounts for 94% of global malaria cases and deaths (1). This life-threatening disease is caused by protozoan parasites of the genus Plasmodium and is transmitted to humans through the bites of infected female Anopheles mosquitoes. Of the five Plasmodium species that infect humans (P. falciparum, P. vivax, P. malariae, P. ovale, and P. knowlesi), P. falciparum is the most virulent, responsible for more than 50% of malaria cases globally and the vast majority of related deaths (2).

The transmission dynamics of malaria are intricately linked to the lifecycle of Anopheles mosquitoes. These mosquitoes go through aquatic developmental stages—eggs, larvae, and pupae—within stagnant water before maturing into adults capable of transmitting the disease. Female mosquitoes require blood meals to develop their eggs, enabling the Plasmodium parasite to spread between human hosts. Factors such as the availability of breeding sites, mosquito longevity, and feeding behaviour significantly influence malaria transmission intensity (3).

Zambia ranks among the top 20 countries with the highest malaria burden globally, with all ten provinces classified as malaria-endemic (1). Despite substantial investments in interventions such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS), malaria remains a leading cause of morbidity and mortality across the country (4) . In Western Province, a predominantly rural area, malaria prevalence has been particularly concerning. Between 2010 and 2018, prevalence rates among children under five years of age doubled from 5% to 10% (5,6).

Western Province's environmental and socio-economic characteristics create a favourable setting for malaria transmission. The region is defined by seasonal flooding, abundant stagnant water, and widespread poverty, all of which contribute to limited access to healthcare and vector control measures. Addressing the rising malaria burden in this province requires context-specific strategies that account for the local ecology and livelihoods.

In recent years, fish farming has gained prominence in Western Province as a vital source of income and food security (7). This growing economic activity has, however, introduced new public health challenges. Poorly managed fishponds provide ideal breeding grounds for mosquitoes, with stagnant water and surrounding vegetation creating conducive habitats for Anopheles mosquitoes (8,9). Research indicates that fishponds are up to four times more likely to harbour Anopheline larvae compared to natural water bodies(10).

While fish farming holds significant potential for poverty alleviation and improved nutrition, its unintended consequences on malaria transmission must be addressed. Understanding how fish farming practices intersect with malaria risk is critical to developing sustainable aquaculture models that minimize public health impacts (11,12).

This study focuses on Mongu District, located in Western Province, to investigate the role of fish farming in malaria transmission. Specifically, it examines whether fishponds serve as breeding grounds for malaria-transmitting Anopheles mosquitoes. Through surveys of 26 fishponds, the research aimed to provide critical insights into the relationship between aquaculture practices and malaria risk, offering evidence-based recommendations to promote sustainable and health-conscious fish farming practices.

By addressing the dual challenges of economic development and public health, the research intended to inform strategies that simultaneously support livelihoods and reduce malaria transmission in malaria-endemic regions like Mongu District.

MATERIALS AND METHODS

The study employed an exploratory, cross-sectional design to examine the presence of malaria-transmitting *Anopheline* mosquito larvae in fishponds within Mongu District, Western Province, Zambia. The study was conducted during the dry-hot season (August to September), a period characterized by reduced rainfall, which creates stagnant water bodies favourable for mosquito breeding. Mongu District was specifically chosen due to its high malaria incidence and the growing prevalence of fish farming as a livelihood activity, which presents potential public health challenges (13,14).

Fishponds included in the study were identified using non-probability sampling techniques, ensuring the inclusion of diverse pond types and management practices. This approach was deemed appropriate given the lack of prior data on mosquito larval presence in fishponds in Mongu District. To the best of the researchers' knowledge, no larval surveys had been conducted in the district's fish farming systems before this investigation.

The exploratory nature of the study was essential, as it allows for a preliminary understanding of a largely unexamined issue (15). Exploratory studies are particularly useful when limited information is available, providing an initial foundation for future, more detailed research. In this context, the study aimed to identify patterns of mosquito breeding in fishponds, laying the groundwork for targeted interventions and policy recommendations to address malaria risks associated with aquaculture.

Study Sites

A total of 26 fishponds (dotted in red in figure 1) were included in the study, encompassing both lined and unlined ponds. Lined ponds featured external water inlets, regular drainage systems, and minimal vegetation. Unlined ponds, in contrast, relied on stagnant groundwater and were characterized by floating and border vegetation. These differences provided an opportunity to compare mosquito breeding patterns across varying pond management practice

Figure 1: Google earth Map showing study sites and a fish farmer (Source: Google Maps).

Larvae Collection
Larvae were collected using a standard 350 ml dipper. For each pond, 10 dips were performed at different locations to ensure representative sampling. The water collected in each dip was poured into a white plastic tray to facilitate observation. Mosquito larvae were identified visually, counted, and transferred into labelled screw-cap containers. Care was taken to leave sufficient airspace in each container to allow the larvae to survive during transportation.

Larvae Preservation
To ensure accurate morphological identification, the larvae were preserved using a two-step process. First, boiling water was poured into the containers for two minutes to fix the proteins and prevent discoloration. This step also eliminated bacteria present in the larvae's gastrointestinal tract. Afterward, the larvae were transferred back into their respective containers and preserved in 70% ethanol. This method maintained the structural integrity of the larvae for subsequent identification.

Morphological Identification
The preserved larvae were transported to the Macha Research Trust, where trained entomologists conducted morphological identification. Due to financial constraints, molecular identification was not performed. However, the morphological techniques employed were sufficient to distinguish between *Anopheline* and *Culicine* mosquito species.

Data Analysis
The collected data were entered into Microsoft Excel for analysis. Descriptive statistics, including percentages and larval densities, were calculated. Results were presented in tables and graphs to highlight the differences in mosquito breeding patterns between lined and unlined ponds.

RESULTS
Pond Type
There were 26 fishponds sampled of which 2 types of ponds were included in the study, that is lined and un-lined ponds.

Figure 2: An unlined fishpond

Figure 3: A lined fishpond

Making reference to the images in Figure 2 and 3, unlined fishponds had a lot of boarder and floating vegetation. The water in these ponds came from the ground with no external water source present and no proper form of an existing water draining technique. Antithetically, lined fishponds had no boarder or floating vegetation, with an external water inlet and a proper draining technique and routine employed where water was drained and replaced once every seven days. The un-lined fishponds where 8, making up 31% and ranged from labels A to H and lined fish ponds where 18, making up 69% and labelled I to Z of the sampled fishponds as summarised in table 1.0.

Table 1.0 pond types, number and range of assigned label

POND TYPE	NUMBER	PERCENTAGES (%)	RANGE OF LABELS
Un-lined fishponds	8	31	A to H
Lined fishponds	18	69	I to Z

Ponds as breeding sites

From the 26 fishponds included in the study, 8 fishponds labelled A to H which were un-lined were breeding sites for mosquito larva. Lined fishponds marked I to Z had no mosquito larvae.

Number of larvae collected from breeding sites

From each fishpond, 10 dips were collected with a scooper. The larvae collected per dip was counted and recorded. A total of 112 larvae were collected from the 8 fishponds labelled A to H that were breeding sites. 27 larvae were collected from pond A, 18 from B, 6 from C while D had 7. Fishpond E had 29 collected larvae whereas fishponds F, G and H had 11, 8 and 6 respectively. Antithetically, fishponds labelled I to Z had no mosquito larvae breeding as shown by the graph in Figure 4.

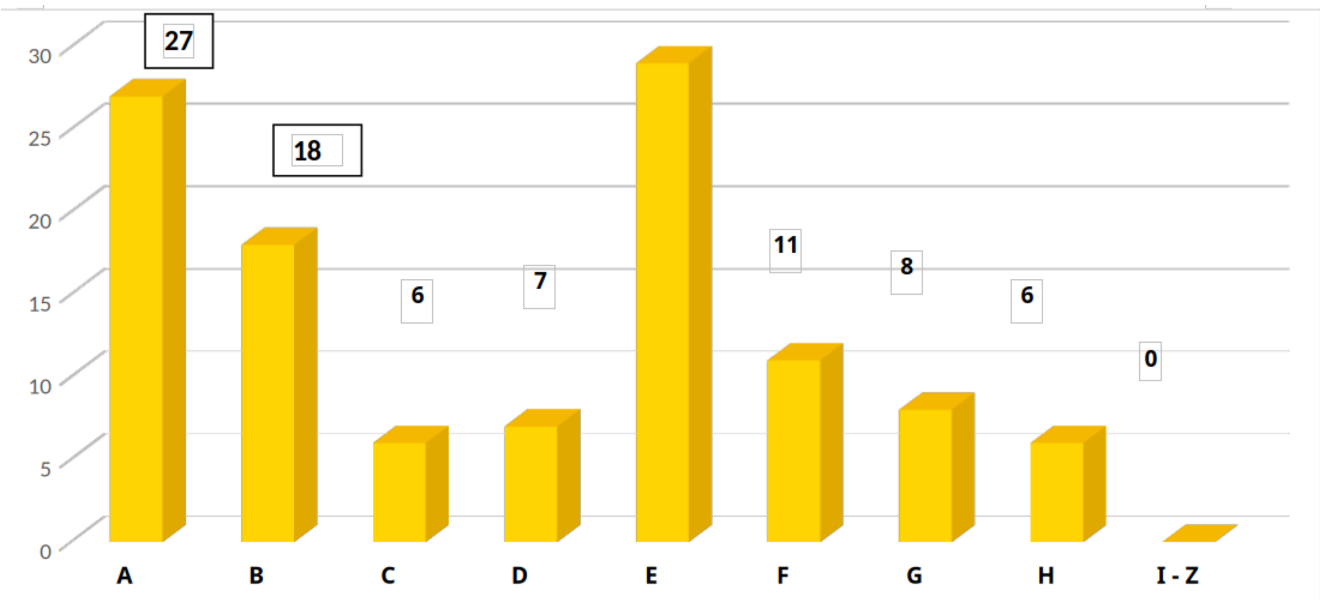

Figure 4

Types of larvae collected per breeding site

Of the 10 dips done in each of the ponds resulting in 260 dips, 112-mosquito larva were collected from fishponds A to H, of which upon identification 29 were anophelines and 83 were identified as culicine mosquito species resulting in 26% and 74% of the collected larva, respectively. Quantification of mosquito larvae density was based on Karibul's method (16) and Calculated as follows:

D= n/N D= Larvae density
D=29/260 n= Total number of Anopheline Larvae
D=0.112 N=Number of Dips Taken

Details of these results are presented in table 2.0

Table 2.0 types of mosquito larva collected per pond

POND	ANOPHELINE	CULICINE
A	6 (22%)	21(78%)
B	2 (11%)	16(89%)
C	2(33%)	4(67%)
D	1(14%)	6(86%)
E	10(34%)	19(66)
F	4(36%)	7(64%)
G	3(38%)	5(62%)
H	1(17%)	5(83%)
I - Z	0(0%)	0(0%)
Total	29 (26%)	83 (74%)

DISCUSSION

A total of 112 mosquito larvae were collected during the study, with 29 (26%) identified as Anopheline larvae (malaria-transmitting) and 83 (74%) as Culicine larvae (non-malaria-transmitting). Interestingly, patterns emerged regarding the types of fishponds that served as breeding sites and how fish populations influenced larval density.

Fishponds with higher fish populations harboured fewer mosquito larvae. This inverse relationship can be attributed to the larvivorous nature of fish, which prey on mosquito larvae, thereby reducing their density. For example, fishponds with no fish, such as ponds A and E, had the highest larval densities (27 and 29 larvae in 10 scoops, respectively). Conversely, ponds with more fish, such as C, D, F, G, and H, had significantly lower larval counts, ranging from 6 to 11 larvae in 10 scoops. These findings align with previous studies, such as one conducted in Kenya, which reported that introducing fish into mosquito-infested ponds led to a 94% reduction in Anopheles mosquito larvae and a 75% reduction in Culicine larvae within 15 weeks(17). These results underscore the importance of fish presence in fishponds as a natural and sustainable mosquito control measure (18).

All the mosquito larvae collected during this study were exclusively found in unlined fishponds. In contrast, no larvae were detected in lined fishponds. This disparity can be explained by two critical factors:

Unlined ponds were surrounded by floating and border vegetation, creating a conducive habitat for mosquito breeding. Anopheles mosquitoes, in particular, prefer laying eggs in uncontaminated water with shade and vegetation(10). Studies have corroborated this, such as one in northwestern Brazil, which found that larval densities increased with the presence of border vegetation(19,20).

In contrast, lined fishponds lacked such vegetation, making them less suitable for mosquito breeding. Unlined fishponds relied on natural groundwater sources and lacked proper water drainage systems, allowing mosquitoes to complete their life cycles undisturbed. Stagnant, unregulated water provides an ideal environment for larvae to thrive (21,22). In contrast, lined fishponds with proper drainage systems are less likely to harbour mosquito larvae, as regular water draining interrupts the mosquito life cycle before eggs hatch or larvae matures. The study's timing and methodology significantly influenced the observed distribution of Anopheline and Culicine larvae.

Sampling was conducted during the dry-hot season (September), a period when Culicine mosquitoes typically dominate due to their preference for warm, dry environments (3). In contrast, Anopheline mosquitoes are more prevalent during the wet season when breeding conditions are more favourable. This seasonal variation was observed in a related study in the Barotse floodplains, where Anopheline larvae were present in 85% of sampling points during the wet season but only 43.3% during the dry season(19,20).

The single sampling period used in this study provided a snapshot of larval distribution but may have underrepresented the true density of Anopheline mosquitoes, which fluctuate seasonally. Studies employing multiple sampling periods across different seasons have reported higher Anopheline densities during the wet season. The study revealed that Culicine larvae outnumbered Anopheline larvae, comprising 74% and 26% of the total larvae collected, respectively. This disparity is likely due to the season of sampling and the single-sampling methodology, as discussed earlier.

Fishpond G had the highest proportion of Anopheline larvae (38%), although overall, Culicine larvae dominated across all ponds. The calculated average larval density was 0.107, reflecting relatively low Anopheline abundance at the time of sampling.

The findings highlight the importance of proper fish farming practices in mitigating malaria transmission risks: These should be avoided or managed carefully to prevent mosquito breeding. The removal of border and floating vegetation can significantly reduce mosquito larval density. Draining pond water at least once every seven days disrupts mosquito life cycles, as observed in lined ponds.

Fish Stocking: Increasing fish populations in fishponds serves as a natural larval control strategy, as fish feed on mosquito larvae.

CONCLUSION

This study underscores the dual role of fish farming as an economic activity and a potential public health challenge. Properly managed fishponds, particularly lined ponds with sufficient fish populations and regular water drainage, can minimize the risk of mosquito breeding. These findings provide a foundation for integrating aquaculture and malaria control strategies, particularly in malaria-endemic regions like Mongu District. Further research incorporating multi-season sampling and broader geographic coverage is recommended to validate and expand upon these findings.

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REFERENCES

1. The E-2020 initiative of 21 malaria-eliminating countries: 2019 progress report.

2. Kassam R, Collins JB, Liow E, Rasool N. Narrative review of current context of malaria and management strategies in Uganda (Part I). Acta Trop. 2015 Dec;152:252–68.

3. Fillinger U, Sombroek H, Majambere S, Van Loon E, Takken W, Lindsay SW. Identifying the most productive breeding sites for malaria mosquitoes in The Gambia. Malar J. 2009 Dec;8(1):62.

4. Zambia - Malaria Operational Plan FY 2019.

5. U.S. President's Malaria Initiative Zambia Malaria Profile.

6. World malaria report 2022 [Internet]. [cited 2025 Feb 11]. Available from: https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2022

7. WorldFish [Internet]. 2018 [cited 2025 Feb 11]. Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor. Available from: https://worldfishcenter.org/publication/aquaculture-zambia-overview-and-evaluation-sectors-responsiveness-needs-poor

8. Krumholz LA. Reproduction in the Western Mosquitofish, Gambusia affinis affinis (Baird & Girard), and Its Use in Mosquito Control. Ecol Monogr. 1948;18(1):1–43.

9. Parasitology Unit, Department of Zoology, University of Ilorin, Ilorin, Kwara State, Nigeria, Babamale OA, Opeyemi OA, Parasitology Unit, Department of Zoology, University of Ilorin, Ilorin, Kwara State, Nigeria, Bukky AA, Parasitology Unit, Department of Zoology, University of Ilorin, Ilorin, Kwara State, Nigeria, et al. Association Between Farming Activities and Plasmodium falciparum Transmission in Rural Communities in Nigeria. Malays J Med Sci. 2020 Jun 30;27(3):105–16.

10. HathiTrust [Internet]. [cited 2025 Feb 11]. The mosquitoes of Oklahoma, by L. E. Rozeboom ... Available from: https://hdl.handle.net/2027/coo.31924018295687?urlappend=%3Bseq=5

11. Maheu-Giroux M. An Eco-Epidemiological Study Of Fish Farming And Malaria Occurrence In The Peruvian Amazon.

12. Matthys B, Vounatsou P, Raso G, Tschannen AB, Becket EG, Gosoniu L, et al. Urban farming and malaria risk factors in a medium-sized town in Cote d'Ivoire. Am J Trop Med Hyg. 2006 Dec;75(6):1223–31.

13. Cross DE, Thomas C, McKeown N, Siaziyu V, Healey A, Willis T, et al. Geographically extensive larval surveys reveal an unexpected scarcity of primary vector mosquitoes in a region of persistent malaria transmission in western Zambia. Parasit Vectors. 2021 Feb 1;14(1):91.

14. Zingani E, Nakweba L. Investigating Practices Among Fish Farmers That Predispose Them To Malaria Infection: An Analytical Cross Section Survey In Mongu And Limulunga Districts Of Western Province, Zambia. J Agric Biomed Sci [Internet]. 2024 Apr 30 [cited 2025 Feb 11];7(2). Available from: https://journals.unza.zm/index.php/JABS/article/view/1132

15. Barlett JE, Kotrlik J, Higgins C. Organizational Research: Determining Appropriate Sample Size

in Survey Research. Inf Technol Learn Perform J. 2001 Jan 1;19.

16. Bashar K, Rahman MdS, Nodi IJ, Howlader AJ. Species composition and habitat characterization of mosquito (Diptera: Culicidae) larvae in semi-urban areas of Dhaka, Bangladesh. Pathog Glob Health. 2016 Mar;110(2):48–61.

17. Howard AF, Zhou G, Omlin FX. Malaria mosquito control using edible fish in western Kenya: preliminary findings of a controlled study. BMC Public Health. 2007 Aug 9;7(1):199.

18. Chandra G, Bhattacharjee I, Chatterjee SN, Ghosh A. Mosquito control by larvivorous fish. Indian J Med Res. 2008 Jan;127(1):13–27.

19. Basabose K. Relationship Between Anophelism Of Fish Ponds And Malaria Transmission At Lwiro-Katana, Eastern Zaire.

20. dos Reis IC, Codeço CT, Degener CM, Keppeler EC, Muniz MM, de Oliveira FGS, et al. Contribution of fish farming ponds to the production of immature Anopheles spp. in a malaria-endemic Amazonian town. Malar J. 2015 Nov 14;14:452.

21. Afrane YA, Lawson BW, Brenya R, Kruppa T, Yan G. The ecology of mosquitoes in an irrigated vegetable farm in Kumasi, Ghana: abundance, productivity and survivorship. Parasit Vectors. 2012 Dec;5(1):233.

22. Fillinger U, Kannady K, William G, Vanek MJ, Dongus S, Nyika D, et al. A tool box for operational mosquito larval control: preliminary results and early lessons from the Urban Malaria Control Programme in Dar es Salaam, Tanzania. Malar J. 2008 Dec;7(1):20.