Hosted by

Investigating Practices Predisposing Fish Farmers to Malaria Infection: An Analytical Cross Section Survey of Mongu and Limulunga Districts of Western Province of Zambia

Ellah Zingani* and Lungowe M. Nakweba
Department of Pharmacy, School of Health Sciences, University of Zambia

* Corresponding author:
Department of Pharmacy, School of Health Sciences, University of Zambia
email: ellahzingani@unza.zm; ellahzinganii@gmail.com

DOI 10.53974/unza.jabs.7.2.1132

ABSTRACT

Malaria is a parasitic disease transmitted between humans through the bite of the infected female *Anopheles* mosquito.

Zambia has recently experienced a growing demand for fish, which is largely triggered by the growing population and an emergent urban middle class within Zambia and neighbouring countries. Various fish farming practices are conducted on small-scale, smallholder and commercial levels. Western Province is among the provinces in Zambia where fish farming is done. In 2014, Zambia became the sixth largest producer of farmed fish (mainly breams – a local name for *tilapia*) in Africa and the largest in the Southern African Development Community (SADC) between 2012 and 2015. From 2012 to 2015, malaria prevalence started to increase from 12.6% to 15.6% in the Western Province of Zambia. This study set out to investigate the practices of fish farmers that predispose them to malaria infection in Mongu and Limulunga districts of Western Province of Zambia. An interviewer-administered questionnaire was used as the data collection tool. Data was analysed using Statistical Package for Social Sciences (SPSS) version 22.

Out of a total of 75 fish farmers, 83% of the participants had good knowledge of malaria, while 17% had poor knowledge, and an association was found between the two highest levels of education (Tertiary and Secondary) and knowledge of malaria according to the chi-squared test ($p<0.005$) and also showed that 73% (n=55) had their ponds near their houses and 3% (n=20) had their ponds far from their houses.

The practices such as lack of draining of ponds, working around the ponds at night without protective clothing and having ponds near households predispose fish farmers to malaria infection in Mongu and Limulunga districts in Western Province, Zambia. Collectively, 21% of the fish farmers practice unsafe fish farming, potentially adding to malaria transmission levels in Western Province of Zambia.

Keywords: Practices, fish farmers, malaria infection, Western Province Zambia.

BACKGROUND

Malaria is a parasitic disease that is transmitted between humans through the bite of the infected female Anopheles mosquito. It is preventable and curable. Four types of parasites can cause malaria in humans: *Plasmodium falciparum, Plasmodium malariae, Plasmodium vivax,* and *Plasmodium ovale.* Plasmodium Falciparum is the most deadly and common, particularly in Zambia and sub-Saharan Africa (Zambia National Malaria Elimination Centre, 2017). Malaria transmission occurs when sporozoites from the salivary glands of mosquitoes are injected into the skin of humans during blood-feeding. Parasites then pass to the liver, where they replicate, each sporozoite yielding many thousands of merozoites, which cause patent infection (Churcher et al., 2017).

The World Malaria Report 2018 estimates that there were 219 million cases of malaria in 2017, with fifteen countries in sub-Saharan Africa and India carrying almost 80% of the global malaria burden. The 10 highest burden countries in Africa reported an estimated 3.5 million more malaria cases in 2017 compared to 2016 (WHO, 2018). In 2019, before the COVID-19 pandemic struck, the number of deaths stood at 568,000. Malaria cases continued to rise between 2020 and 2021 but at a slower rate than in the period 2019 to 2020. The global tally of malaria cases reached 247 million in 2021 compared to 245 million in 2020 and 232 million in 2019 (WHO 2022).

Zambia has recently experienced a growing demand for fish, which is largely triggered by the growing population and an emergent urban middle class within Zambia and neighbouring countries. Various fish farming practices are carried out on small-scale, smallholder and commercial levels in Zambia (Aquaculture in Zambia: An overview and evaluation of the sector's responsiveness to the needs of the poor, 2017).

In 2014, Zambia became the sixth largest producer of farmed fish (mainly breams – a local name for tilapia) in Africa and the largest in the Southern African Development Community (SADC) (Tran et al., 2018). Western Province is among the provinces in Zambia where fish farming is done. It has limited arable land resources to sustain crop production due to difficult geographical and climatic conditions. The mainstay of the people in this province is low subsistence-oriented agriculture with low productivity in crop and livestock production supplemented by fishing (Akakenenwa, 2016). Between 2012 and 2015, the malaria prevalence started to climb from 12.6 to 15.6 % in Western Province (Elisabeth Wilhelm – Malaria elimination front advances to Western Province in Zambia, 2016).

Due to the paucity of published data on fish farming practices and malaria transmission, it is not certain if fish farming contributed to the increase in malaria incidences in the Western Province.

A study by Zingani et al., (2017) in Milenge district of Muchinga Province in Zambia found a link between socio-cultural and socioeconomic practices on malaria control interventions.

A study conducted in the Brazilian Amazon (in the study period 2003 – 2013) revealed that fish farming had contributed to the receptivity of the Northwest Stratum to Malaria. It also revealed over 800 malaria cases for every 1,000 inhabitants, based on data collected from 55 riverbanks. The relationship between the geolocation of malaria cases and their distance to fishponds was investigated in the same area. The results suggested that fish farming contributed to maintaining high malaria transmission levels in that region (Dos Reis et al., 2015).

A cross-sectional survey of malaria prevalence done by (Maheu-Giroux et al., 2010) in Peru reported that the presence of a fishpond close to the house was a risk factor for Plasmodium falciparum malaria and also found evidence of fish pond density as a major risk factor for malaria transmission.

A study by Cristina et al., (2015) in the Amazon Frontier in Brazil that looked at the contribution of fish farming ponds to the production of immature Anopheles spp found that fishponds were, on average, four times more infested with anopheline larvae than natural water bodies. These findings were similar to a previous study done in 2008 in Manaus, Brazil, where fishponds were also four times more infested than other available mosquito breeding sites (Iléa Brandão Rodrigues, 2013).

Another study conducted in the Peruvian Amazon found that there were high numbers of self-reported malaria episodes in households located closer to fishponds (Simpson et al., 2006). In Cruzeiro do Sul, Acre, a study observed an increase in malaria transmission after excavating 179 new fishponds (Costa et al., 2010).

According to the National Malaria Strategic Plan, the Western Province is one of the provinces with a variation in infection prevalence, with high levels (11 to 20%) recorded in Mongu and Limulunga districts of the Western Province, where fish farming is also practiced (Zambia National Malaria Elimination Centre, 2017).

This study aimed at investigating and analysing practices by fish farmers in Mongu and Limulunga districts of Western Zambia that predispose them to malaria infection. Understanding the relationship between fish farming practices and malaria will help the Ministry of Health (MOH), the Ministry of Fisheries and Livestock, and other policymakers develop effective strategies and interventions to address malaria control barriers. The study results can be used to develop malaria control measures that would significantly reduce the high prevalence of malaria in Mongu and Limulunga districts, where fish farming is a way of life.

MATERIALS AND METHODS

This study investigated practices among fish farmers that predispose them to malaria infection. The sites were selected because they record high incidences of Malaria and being two

of the districts in which fish farming is practiced in the Western Province of Zambia. A cross-sectional analytical survey was utilised and involved fish farmers who own and work in fish farms in Mongu and Limulunga districts in Western Province and was conducted between May and July 2021. According to the Ministry of Fisheries and Livestock, there were 45 fish farmers in Mongu District and 30 in Limulunga District. The two districts are socioeconomically similar. The total number of fish farmers from both districts (45+30) were included in the study using a census sampling technique, which entailed recruiting all fish farmers in both districts during the study period. Data was collected using an interviewer-administered, previously pre-tested and structured questionnaire that sought information on demographics, transmission factors, knowledge about malaria infection and fish farming practices.

Demographic characteristics of farmers included sex, district, education level, and occupation. It also included investigating the knowledge fish farmers had about malaria and pond management. The study participants had to tick the appropriate boxes for each option. Names were not used for identification, but coding numbers were used instead. Dependent variables included income, education, and fish farming practices, whereas independent variables included education, age, marital status, and employment.

Questionnaires were checked for completeness and internal consistency. Responses were coded, categorised and entered into a database created on computer software. The database was backed up on storage devices, and hard-copy questionnaires were retained by the researcher.

Quantitative data was analysed using statistical package for social sciences (SPSS version 22) software (from IBM Inc). The data was presented in tables and bar charts, whereas inferential statistical methods such as Pearson's chi-square test were used to determine associations between dependent and independent variables. For statistical inference, a p-value < 0.05 was indicative of statistical significance using a confidence interval of 95%. Results were displayed in the form of tables that were appropriate.

RESULTS

A total of 75 participants were assessed, of whom 60% were from Mongu and 40% were from Limulunga. Of the participants, 82.7% were male and 17.3% were female. With regard to the level of education, 22.7% had gone up to primary, 62.7% secondary and 14.7% tertiary. In terms of occupation, 93.7% (70) sourced income from just being fish farmers, whereas the others had another source such as teaching and fish farming at 4% (3), and teachers who were also pond managers stood at 2.7% (2) as shown in Table 1.

Table 1: Socio-demographic data of participants

Variable	Frequency	Percent
Gender		
Male	62	83
Female	13	17
Total	**75**	**100.0**

Level of Education		
Primary	17	22.6
Secondary	47	62.6
Tertiary	11	14.6
Total	**75**	**100.0**
Occupation		
Fish Farmer	70	93.3
Teacher/FF	3	4.0
Teacher/PM	2	2.7
Total	**75**	**100.0**

Key: a= statistically significant difference in sex, level of education and occupation. b= No statistical significance in the district.

FF= Fish Farmer PM= pond Manager

All the participants knew mosquito bites caused malaria. Regarding sleeping under a mosquito net being preventive, 97.3% agreed, whereas 2.7% disagreed. As a measure of controlling malaria by cutting long grass around the fishponds, 62.7% agreed, and 37.3% disagreed, as shown in Table 2.

Table 2: Malaria Knowledge of fish farmers

Variable	Yes	No
	%(n)	%(n)
Caused by Mosquito	100 (n=75)	
Sleeping under the bed net	97.3 (n=73)	2.7 (n=2)
Wearing long-sleeved clothes	61.3 (n=46)	38.7 (n=29)
Cutting long Grass	62.7 (n=47)	37.3 (n=28)

a=statistical significance in responses to knowledge on malaria.

Regarding mosquito breeding sites and favourable conditions that encourage breeding, 97.3 had good knowledge, whereas 2.7 had poor knowledge, as shown in Table 3.

a= Statistical significance in responses to knowledge and favourable conditions for mosquito breeding.

Table 3: Participant's response to knowledge of mosquito breeding sites and Conditions that favour Mosquito breeding

Variable	Frequency	Percent
Do you know where mosquitoes breed Yes?	73	97.3
No	2	2.7
Characteristics	73	97.3
1) Stagnant water	2	2.7
Yes	70	93.3
No	5	6.7
2) Nighttime	45	60
Yes	30	40
No	64	85.3
3) Dark	11	
Yes	58	14.7
No	17	77.3
4) Draining stagnant pond water		22.7
Yes	73	97.3
No	2	2.7
	73	97.3
5) Clearing bushes and tall grass	2	2.7
Yes	70	93.3
No	5	6.7
	45	60
	30	40
	64	85.3
	11	
	58	14.7
	17	77.3
		22.7

Furthermore, the participants were asked about good fish farming and pond management practices that reduce mosquito breeding and biting while working around fishponds. Of the participants. 73.3% (n=55) had ponds near their houses, and 2.7% (n=20) had their ponds far from their houses, p<0.0001. A total of 82.7% agreed that mosquito breeding could be controlled by cleaning the ponds, and 17.3% disagreed, p<0.0001. All the participants agreed that they cleaned their ponds. Of all the participants, 70.7% agreed that draining their fish ponds was a good practice to prevent mosquito breeding, and 20.3% disagreed, p<0.0001. Interestingly, only 20% (n=15) clean their ponds daily, whereas 80% (n=60) do not clean their ponds daily, p<0.0001. 84.0% (64) said they work around the fish ponds at night, and 16% (11) did not, p<0.0001. Of the 64 participants who worked around the ponds at night, 31 said they wore protective clothing such as gum boots, head covers and long-sleeved clothes to prevent mosquito bites, and 33 did not p<0.001. All the participants agreed that they have larvivorous fish species in their ponds. 66.7% (n=50) said they had put measures such as draining the fish ponds and cleaning the areas around the fish ponds to prevent breeding, whereas 33.3% (n=25) had not, p<0.004 as shown in Table 4.

Table 4: Participant responses to good fish farming and pond management practices to prevent mosquito breeding

Variable	Response	Frequency	Percent
• How far is the pond from the house?	Near	55	73.3
	Far	20	26.7
• Mosquito breeding is prevented by cleaning ponds.	Yes	62	82.7
	No	13	17.3
• Cleaning the ponds?	Yes	75	100.0
	Yes	15	20.0
• Clean ponds daily to remove debris.	No	60	70.7
	Yes	53	29.3
• Draining of Ponds?	No	22	84.0
	Yes	63	16.0
• Any activities done around the pond at night?	No	12	41.3
	N/A	31	42.7
• Do you wear protective clothing when working around the pond at night? (Out of the 63 that work around the ponds at night). Larvivorous fish?	Yes	32	16.0
	No	12	100.0
• Do you have measures to limit mosquito population?	Yes	75	66.7
	No	50	33.3
		25	

a= statistical significance in responses to good fish farming and pond management practices. N/A= Not Applicable

DISCUSSION

This study aimed at investigating the practice by fish farmers that predisposes them to malaria in Limulunga and Mongu districts of Western Province of Zambia. A total of 75 participants involved in fish farming were assessed, of whom 62 were male and 13 were female. A total of 62 out of 75 participants knew about malaria concerning its cause, mosquito breeding and preventive measures. This could be attributed to the fact that 62.7% (n=42) of the participants had attained secondary education and 14.7 %(n=11) had tertiary education, and an association was found between the two highest levels of education and knowledge of malaria. This is in contrast to a study that was done in Nigeria by Oladepo et al., (2010) in two rural agricultural farming communities in Oyo State, which found that 403 randomly selected farmers had a low level of knowledge of malaria causation as only 12.4% stated that mosquito bite could transmit the disease. Less than half (46.7%) correctly mentioned the signs and symptoms of malaria Oladepo et al., (2010). The study in Delhi by Matta et al., found that out of 150 respondents, only 40.6% knew preventive measures for Malaria, and 34% answered that mosquito nets were the prime preventive measure against mosquito bites (Matta et al., 2014).

This study found no association between knowledge of malaria and practices that promote mosquito breeding with the respondents' social demographic characteristics. Similar results were reported in a study by Stephens et al. in the Dar-es-salaam and Tanga provinces of Tanzania, which looked at mosquito knowledge concerning public and domestic control activities in the two districts. However, this contrasts with Oladepo et al., (2010) who found a significant association between respondents' knowledge about malaria and agricultural practices that promote mosquito breeding. The contrast is because Oladepo et al., (2010) considered the respondents' wealth quintile level, which was also seen to be associated with respondents' knowledge about malaria and agricultural practices which promote mosquito breeding. Oladepo's study reflects the findings in the study by Zingani et al., (2017) done in Milenge district in Luapula Province of Zambia, where most of the participants' source of income was fishing and agriculture; that low socio-economic status was the main key factor affecting malaria control interventions (Zingani et al., 2017).

Regarding fish farming and good pond management that prevents mosquito breeding, 55 (73.3%) had fish ponds near their houses. In the Iquitos-Nauta Road, Peru, Simpson et al., found higher numbers of self-reported malaria episodes in households closer to fishponds, which were the most commonly positive larval habitats in this area. All the participants agreed that they cleaned and drained the ponds, and 20% (n=15) said they cleaned the pond daily. Poorly managed fishponds have sometimes been associated with the presence of Anopheles species (Maheu-Giroux et al., 2010) and, consequently, with malaria transmission.

Of the participants, 82.7% (n=62) acknowledged that keeping the pond clean by draining water and clearing surroundings by cutting grass prevents mosquito breeding. This finding is similar to that of Oladepo et al., (2010) who found a significant association between knowledge about malaria and agricultural practices. Out of 75, 64 participants said they work around the ponds at night, and 31 wore protective clothing with long sleeves or overalls covering the body, headgear and gumboots to prevent being bitten by mosquitoes. All the participants said the fish in their ponds was larvivorous, but this is insufficient to show whether larvivorous fish reduce the density of larvae or adult mosquitoes.

Findings from previous studies, such as that of Rodrigues et al., in Manaus, Brazil, found fishponds to be four times more infested than other available mosquito breeding sites (Rodrigues et al., 2008). Fishponds were also identified as breeding sites for *Anopheles darlingi* in the north-eastern Peruvian Amazon (Vittor et al., 2009), where the presence of fishponds was a risk factor for human malaria transmission (Maheu-Giroux et al., 2010) despite potential larval predation by juvenile fish (Vittor et al., 2009).

The limitations of this study were that it did not include observation over a period of time of the activities of the participants in relation to fish farming practices and good pond management, and the participants may not have given honest answers. The researcher did not collect any larvae or adult mosquito samples for laboratory analysis to ascertain if there are those of malaria-transmitting mosquitoes.

CONCLUSION

Fish farming (Aquaculture) has become a good source of income for communities in the Western Province that contributes to Zambia's economy and alleviates poverty, contributing significantly to the socioeconomic status of individuals in the district.

The study found that 21% of the 75 fish farmers are predisposed to malaria due to bad practices, which may contribute to the ongoing transmission and number of cases of malaria in the two districts, Mongu and Limulunga, in the Western Province of Zambia.

Investments in fish farming should be followed by a malaria control programme suitable for the communities in Mongu and Limulunga districts that are in tandem with the socioeconomic practices in that region.

The relevance of this study is that stakeholders, especially the Ministry of Health, and the Ministry of Agriculture, Fisheries and Livestock, better understand the relationship between fish farming practices and malaria.

AVAILABILITY OF DATA AND MATERIALS

The data sets used and/ or analysed during the current study are available from the corresponding author upon reasonable request.

COMPETING INTERESTS

The authors declare that they have no competing interests.

FUNDING

There was no funding.

AUTHORS CONTRIBUTION

Ellah Zingani conceptualised the study and developed the protocol. Lungowe

Nakweba supervised the collection of data and analysis of the data. Both authors contributed to the development of this article.

ACKNOWLEDGEMENTS

The staff at the Ministry of Agriculture, Fisheries and Livestock Western provincial office and the fish farmers of Mongu and Limulunga districts, Western Province of Zambia, thank the study participants.

REFERENCES

1. Akakenenwa M. (2016). Civil Society for Poverty Reduction - Brief Profile of Western Province. Mongu.
2. Churcher TS. (2017). Probability of Transmission of Malaria from Mosquito to Human is Regulated by Mosquito Parasite Density in Naïve and Vaccinated Hosts', pp. 1–18.
3. Consoli R, Lourenço-de-Oliveira R. (2010). Principais Mosquitos de Importância Sanitária no Brasil. Rio de Janeiro: Fiocruz; 2010.
4. Costa KM, de Almeida WA, Magalhaes IB, Montoya R, Moura MS, de L. M. (2010). 'Malaria in Cru-zeiro do Sul (Western Brazilian Amazon): Analysis of the Historical Series from 1998 to 2008', Panam Salud Publica, (28), pp. 353–360.
5. Cristina I. (2015). Contribution of Fish Farming Ponds to the Production of Immature Anopheles spp. in a Malaria - Endemic Amazonian Town', *Malaria Journal. BioMed Central*, pp. 1–12.
6. Dos Reis IC. (2015). Epidemic and Endemic Malaria Transmission Related to Fish Farming Ponds in the Amazon Frontier', PLoS ONE, 10(9).
7. Elisabeth W. (2016). Malaria Elimination Front Advances to Western Province in Zambia, 23 June 2016. www.makingmalariahistory.org/malaria-elimination-front-advances-to-western-province-in-zambia. Accessed on 04-05-2019.
8. Zingani E, Mtonga G, Kalungia AC, Mukosha M, Banda A. (2017). Socio-economic and Socio-cultural Factors Affecting Malaria Control Interventions in Zambia: A Survey of Milenge district, Luapula Province. Zambia. *Journal of Preventive and Rehabilitative Medicine,* Vol. 1, No. 1, 2017, pp. 5-11. doi: 10.21617/jprm.2017.0102.1.
9. Genschick S, Kaminski AM, Kefi AS, Cole SM. (2017). Aquaculture in Zambia: An Overview and Evaluation of the Sector's Responsiveness to the Needs of the Poor (2017).
10. Iléa BR, Wanderli PT, Jose M. C. da S.D. (2013). Larvicidal Activity of Bacillus Sphaericus 2362 Against Anopheles nuneztovari, Anopheles Darlingi and Anopheles Braziliensis (Diptera, Culicidae', BioAssay: pp. 1–7.
11. Maheu-Giroux M, Casapía M, Soto-Calle VE, Ford LB, Buckeridge DL, Coomes OT, Gyorkos TW. (2010). Risk of Malaria Transmission from Fishponds in the Peruvian Amazon. Acta Trop. 2010 Jul-Aug;115(1-2):112-8. doi: 10.1016/j.actatropica.2010.02.011. Epub 2010 Feb 25. PMID: 20188688.

12. Matta S, Khokhar A, Sachdev TR. (2014). Assessment of Knowledge about Malaria among Patients Reported with Fever: A Hospital-based Study, Department of Community Medicine, VMMC and Safdarjang Hospital, New Delhi; J Vect Borne Dis 41, March and June 2014, pp 27–31.
13. Oladepo O, Tona GO, Oshiname FO. (2010). Malaria Knowledge and Agricultural Practices that Promote Mosquito Breeding in Two Rural Farming Communities in Oyo State, Nigeria. Malar J 9, 91 (2010). https://doi.org/10.1186/1475-2875-9-91.
14. Rodrigues IB, Tadei WP, Santos RC, Santos SO, Bagio JB. (2008). Malaria Control: Efficacy of Bacillus Sphaericus 2362 Formulates against Anopheles Species in Artificial Pisciculture Tanks and Breeding Sites in Pottery areas. Rev de Pat Trop. 2008; 37:161–77. Google Scholar.
15. Simpson JM. (2006). Aquaculture Production, Contributing to Malaria Transmission in the Peruvian Amazon. MA Thesis. Columbia University.
16. Stephens C, Masamu ET., Kiama MG, Keto AJ, Kinenekejo M, Ichimori K, and Lines J., (2015). Knowledge of Mosquitos in Relation to Public and Domestic Control Activities in the Cities of Dar es Salaam and Tanga, WHO Bulletin OMS. Vol. 73 2015.
17. Tran N. (2018). Fish Supply and Demand for Food Security in Sub-Saharan Africa: An Analysis of the Zambian Fish Sector', (November).
18. Vittor AY, Pan W, Gilman RH, Tielsch J, Glass G, Shields T, et al. (2009). Linking Deforestation to Malaria in the Amazon: Characterisation of the Breeding Habitat of the Principal Malaria Vector, Anopheles Darlingi. Am J Trop Med Hyg. 2009; 81:5–12.
19. WHO (2018). World Malaria Report 2018.
20. Zambia National Malaria Elimination Centre (2017). National Malaria Elimination Strategic Plan, 2017-2021 Moving from Accelerated Burden Reduction to Malaria Elimination in Zambia'. Available at: http://www.makingmalariahistory.org/wp-content/uploads/2017/06/NMESP_2017-21.