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Targeting Simulium Vectors to Accelerate Control of Onchocerciasis in the Mahenge Area, Tanzania: A Systematic Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Systematic Review Article

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ABSTRACT

Background: The Mahenge Mountains in south-eastern Tanzania remain a persistent onchocerciasis hotspot despite many years of community-directed ivermectin (CDTI) distribution. The disease is primarily transmitted by *Simulium* species, especially members of the *Simulium damnosum* complex.

Aims: This review brings together current evidence on vector-targeted interventions, including entomological surveillance, larviciding, and environmental management in Mahenge and comparable Tanzanian foci. This review aims to assess whether integrating vector control with ongoing CDTI could help accelerate the interruption of transmission.

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Methods: A comprehensive search was conducted across PubMed, Scopus, Web of Science, African Journals Online, WHO repositories, Google Scholar, and relevant grey literature, with no date limits. Search terms combined *Simulium* or blackfly, onchocerciasis, Mahenge or Tanzania, and vector-control related keywords. The study included field studies, operational reports, modelling papers, and entomological surveys that reported on vector species composition, breeding-site mapping, vector-control activities, or outcomes related to transmission. Two reviewers independently screened articles and extracted data. Quantitative findings were pooled when appropriate; otherwise, results were synthesised narratively.

Results: Historical studies confirm *S. damnosum s.l.* as the dominant vector in Mahenge. Recent reports highlight ongoing transmission despite long-term ivermectin use and recommend supplementing CDTI with vector control. Evidence from other Tanzanian foci and modelling work suggests that well-implemented larviciding grounded in comprehensive breeding-site mapping and applied consistently can substantially reduce biting rates and shorten the time needed to achieve elimination compared with CDTI alone. Programmatic documents describe both successful reductions in vector density and episodes of transmission rebound when larviciding was incomplete or discontinued. However, there is still a shortage of published field trials from Mahenge directly evaluating the impact of larviciding, with most available studies being descriptive, model-based, or operational.

Conclusions: The available evidence supports integrating targeted *Simulium* control, particularly larviciding accompanied by strong entomological surveillance, with existing CDTI in high-transmission areas such as Mahenge. Key priorities include: (1) updated breeding-site mapping using tools such as drone imagery with ground-truthing, (2) larval susceptibility testing to guide larvicide choice, (3) pilot larviciding accompanied by rigorous environmental and entomological monitoring, and (4) long-term investment in local capacity. Well-designed operational trials in Mahenge, using both entomological and epidemiological endpoints, are urgently needed to guide effective elimination strategies.

Keywords: Onchocerciasis; Simulium; vector control; larviciding; Mahenge; Tanzania; systematic review.

1. Introduction

Onchocerciasis (river blindness), caused by Onchocerca volvulus and transmitted by Simulium blackflies, remains a public-health issue in several foci despite decades of mass ivermectin distribution (Crump et al., 2012; WHO, 2025). A wide range of *Onchocerca* species have been reported to infect human including those that infect domestic and wild animals (Cambra-Pellejà et al., 2020). Worldwide, Onchocerciasis affects about 198 million people in 36 countries in which onchocerciasis is prevalent (WHO, 2025). Current studies have reported that more than 20.9 million people are infected with onchocerciasis, with over 14.6 million people having onchocercal dermatitis and 1.15 million people having vision loss (WHO, 2025), with over 381,000 people living with onchocerciasis-associated epilepsy (OAE) the condition which is responsible with disability (Boatin & Richards, 2006; Bhattacharyya et al., 2023).

Tanzania experiences a year-round transmission of onchocerciasis, with more than 6 million people at risk of acquiring the disease in six endemic regions (Greter et al., 2018). The Mahenge Mountains in south-eastern Tanzania were historically a high-prevalence focus and are the most heavily infected foci for onchocerciasis (Mushi et al., 2024; Bhwana et al., 2019). The area has an estimated nodule prevalence of 95–100% in some communities and microfilariae prevalence of 60–87% (Bhwana et al., 2022; Mushi et al., 2024; Mmbando et al., 2018). Despite two decades of annual CDTI implementation, there is persistent onchocerciasis transmission (Mushi et al., 2024; Mmbando et al., 2018) with an increasing rate of OAE (Mushi et al., 2024). Although the Ivermectin-based community-directed treatment (CDTI) has reduced morbidity among communities, it is insufficient to interrupt transmission in the Mahenge foci (Mushi et al., 2024). This is due to a number of factors, including high vector abundance and stable breeding sites (Hendy et al., 2018; Häusermann, 1969), incomplete CDTI coverage, such as the hard-to-reach homes and absence of individuals in their homes during CDTI visits (Mushi, 2018) and incomplete or suboptimal patterns such as individual compliance to treatment (Mushi, 2018).

Vector control targeting aquatic blackfly larviciding, historically considered pivotal in early control programs, can accelerate interruption of onchocerciasis transmission when combined with MDA/CDTI (Colebunders et al., 2019). This systematic review examines available evidence on *Simulium* surveillance and control in Mahenge foci and comparable Tanzanian foci, to inform whether targeted vector interventions could accelerate control.

2. Methods

2.1 Review Design

Information sources and search strategy used: A systematic review was conducted following PRISMA 2020 guidelines (Page et al., 2021). The protocol specified databases, search strategies, selection criteria, data extraction fields, and risk-of-bias assessments. The database search included PubMed, Scopus, Web of Science, African Journals Online (AJOL), WHO IRIS and Google Scholar (grey literature). The search involved specific terms such as combined MeSH and free-text terms: (onchocerciasis OR "river blindness") AND (simulium OR blackfly OR black fly OR diptera) AND (control OR larviciding OR BTI OR temephos OR "vector control" OR "integrated vector management") AND (Africa OR Tanzania OR Mahenge). The inclusion criterion in this search was: Inclusion Criteria; Publication between 1980–2024 in English, study should be on vector control in onchocerciasis, Entomological studies on biting rates, vector ecology, breeding sites, Intervention trials, program evaluations, modelling studies, studies relevant to Africa, especially in East Africa. For Exclusion Criteria: studies not involving *Simulium* vectors, non-African studies without ecological relevance and opinion pieces without data. The number of records identified by PRISMA 2020 through the database was as detailed in (Fig. 1).

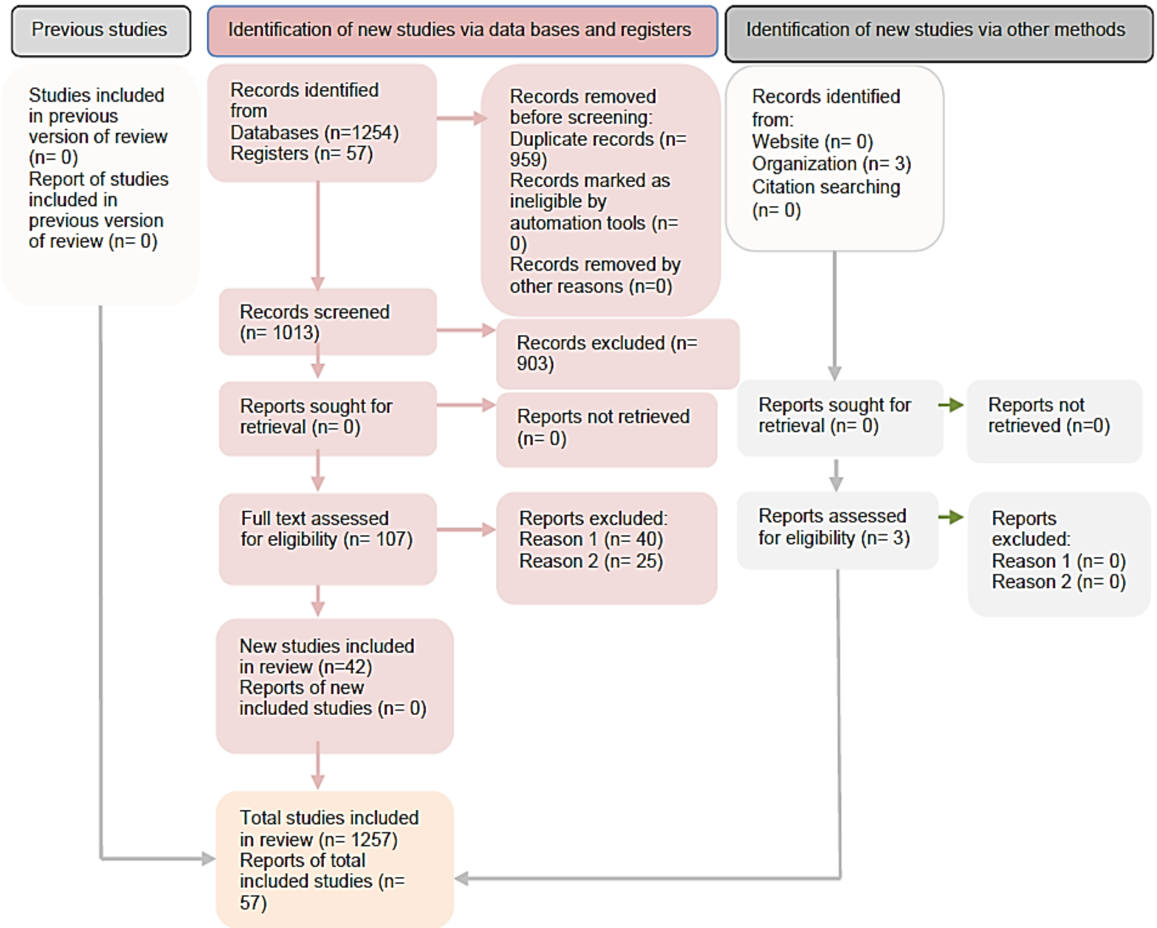

Fig. 1. Prisma flow diagram

Selection process and data extraction: All records were imported into Mendeley reference manager, then duplicates were removed. For screening two independent scientists were identified (as reviewers) to screen the collected study titles and abstracts. Then, full-text screening was conducted by the two independent reviewers. The extracted variables included study design, location, vector species, intervention details, outcomes, and programmatic notes. There was no disagreement.

Synthesis method: Given the heterogeneous nature of study designs observed and outcomes, the study performed a narrative synthesis to summarise intervention types and outcomes.

3. Results: Narrative

Characteristics of included studies: Historical entomological studies documenting *Simulium* biology in Mahenge; entomological surveillance reports and programs advocating combined CDTI and vector control; operational reports from other Tanzanian foci (e.g., Tukuyu) that implemented larviciding; and modelling studies demonstrating benefits of larviciding on reducing biting rates and time to elimination. No randomised or controlled field trials were identified for Mahenge specifically.

Vector species and breeding sites: The Mahenge area is characterised by the presence of riverine, dry lowland and submontane forests, home to *S. damnosum* s.l. as the primary vector of Onchocerciasis in Mahenge. The mountains are drained by numerous stony streams and rivers favourable to blackfly breeding (Häusermann, 1969; Hendy et al., 2018). Historically (older entomological surveys), the common Cytoforms in Mahenge are the 'Nkusi', *S. Plumbeum* (Ketaketa and 'Hammerkopi'), Sebwe and Turiani (Krüger et al., 2005). 'Nkusi' is the predominant anthropophilic species sustaining most of the transmissions in Mahenge (Krüger et al., 2005). While *S. Plumbeum* has a limited role in human biting, 'Sebwe' and 'Turiani' are primarily zoophilic (Krüger et al., 2005; Häusermann, 1969). Recent molecular/cytogenetic survey has confirmed cytoforms in Mahenge as 'Nkusi', *S. kilibanum* and 'Turiani', and *S. nyasalandicum* (which appears to be restricted to higher altitudes) (Hendy et al., 2018). Studies also indicated the influence of seasonality (wet and dry) in *Simulium* complex abundancy and transmission intensity, which are important indices in control efforts (seasonality, breeding microhabitats) (Häusermann, 1969; Hendy et al., 2018). Recent entomological surveillance highlights that some breeding sites are in hard-to-reach areas, making it difficult for mapping and delivery of larvicides and calls for innovative mapping approaches (Mushi, 2023).

Interventions and outcomes: Evidence from Tanzanian foci (Tukuyu) (Kalinga et al., 2007) and other African programs shows that larviciding can substantially reduce larval densities and biting rates to more than 90% (Cheke et al., 2008; Kleinerman et al., 2021; Garms et al., 2009; Lakwo et al., 2017; Schwan et al., 2012; Jacob et al., 2018). Studies from African programmes managed to eradicate onchocerciasis through ground larviciding when applied comprehensively and repeatedly (Zarroug et al., 2016; McMahon et al., 1958; Garms et al., 2009; Lakwo et al., 2006). However, incomplete coverage, underdosage or interrupted dosing resulted in recrudescence in some historical programs (Maegga et al., 2018). Thus, susceptibility testing (e.g., temephos) is essential where organophosphates are considered for the community-directed vector control (MoH, 2023). Mathematical modelling has suggested that adding vector control to CDTI accelerates the decline in Annual Bitting Rates (ABR) and reduces time to interruption of transmission, particularly in areas with persistent transmission despite good CDTI coverage (Higazi et al., 2013). Combined interventions are therefore more effective than MDA alone (Routledge et al., 2018). Given the ecological complexity of Mahenge, studies propose drone-based mapping and remote sensing for effective mapping of hard-to-reach breeding sites. This will help the identification of inaccessible breeding sites and guide plans for targeted interventions (Mushi, 2023). This approach can reduce field search time and improve placement of ground teams, though a drone. Larvicide delivery still requires experimental, regulatory and review (Mushi, 2023).

Risk of bias and quality of evidence: Many of the studies are observational or programmatic reports lacking controlled designs. Modelling studies rely on assumptions which do not currently consider details of the population dynamics of the vectors and local ecological heterogeneities. This could lead to misleading results because *Simulium* population dynamics and vector ecology have important effects on the implementation and outcomes of several aspects

Table 1. Expected impact and timeframe of combined *Simulium* spp vector control and community directed ivermectin intervention (CDTI)

Intervention (Combined With CDTI)	Impact on Simulium Density	Time for reduction in Vector Density / Epidemiological Impact (↓ mf, Ov16, and ATP)	References
Temephos (Abate®) + CDTI	80–95% reduction in larval survival and rapid reduction in biting rates **(1–2 weeks)**	**(1–3 years**) Requires weekly or biweekly application to achieve marked reductions in mf prevalence and ATP	(WHO, 2016 ; Lakwo et al., 2006; Traoré et al., 2009; Kamtsap et al., 2023
Bti Larviciding + CDTI	60–90% Reduction in larval density; biting density **(2–3 weeks)**	**(2–4 years)** Requires weekly or biweekly, application for sustained reduction in microfilaria prevalence/OV16	(Lacey et al., 1982; Kamtsap et al., 2023; de Moor & Car, 1986)
Slash-and-Clear + CDTI	30–80% Reduction in biting rate **(2–6 weeks)**	**(3–5 years**) When repeated every 2–3 months can accelerate decline in entomological indices (parity rate, infectivity rate)	(Smith et al., 2019); Raimon et al., 2021; Jacob et al., 2021)

of vector control (Basáñez et al., 2016). Also, there is a scarcity of robust, site-specific experimental evaluations of larviciding outcomes, especially in Mahenge. Thus, the overall quality of direct evidence for Mahenge is minimal except that indirect evidence from similar foci and models is supportive.

4. Discussion

Mahenge remains an important, historically high-intensity focus of onchocerciasis in Tanzania with *Simulium damnosum s.l.* as the main vector. There have been long-standing challenges in interrupting transmission with ivermectin alone, particularly in remote mountain communities. Classic entomological work describing vector biology in Mahenge dates back (Häusermann, 1969; Hendy et al., 2018), and recent calls for supplementing community-directed treatment with ivermectin (CDTI) with vector control are rising. This is because, despite 25 years of annual CDTI, the prevalence of onchocerciasis and associated epilepsy remains high in rural villages of Mahenge (Mushi et al., 2024), indicating ongoing transmission and the need to combine vector control with CDTI is pivotal (24).

Operational experiences from African programmes on vector elimination to supplement the ongoing ivermectin mass distribution programme indicate that, ground larviciding (targeting aquatic *Simulium* larvae) with organophosphates such as temephos (Abate®)(33)(21) or with microbial larvicides (Bti/Bs) (34)(35)(36) can dramatically reduce biting rates when implemented with sufficient spatial coverage and frequency (37). Similar observation was reported in other Tanzanian foci (e.g., Tukuyu) (18). Studies show that weekly applications to fast-flowing rivers reduce *Simulium* larvae by 80–95%. OCP demonstrated near-complete interruption of transmission within 6–10 years in many river basins (19)(20)(21)(22)(23)(24). However, careful mapping of breeding sites, trained teams, and environmental monitoring were highly recommended for effectiveness (33)(21). There is a documented history of vector elimination and subsequent recrudescence where operations were not sustained, or monitoring was weak (28)(38). The implementation of the environmental management strategy was evidenced through the slash and clear method, which reported a reduction in biting rates by 89%-99% within a short period of implementation (39)(40). Studies on the slash and clear method reported the disappearance of flies within a few months of implementation (39)(40). Modelling studies show that combining CDTI with vector control accelerates reduction in transmission by 30–60% and shortens the time to elimination compared with MDA/CDTI alone, particularly in high-transmission foci (41). Thus, combining larviciding with CDTI can potentially save more than 10 years of interventions compared to relying on annual MDA/CDTI alone and cost-saving in the medium term in persistent foci (42)(31).

Effective implementation of the vector control programme, such as the slash and clear method in Mahenge, will require effective mapping of breeding sites within 2 km of the at-risk communities. Since *Simulium damnosum s.l.,* the primary vector of *O. volvulus*, only lay their eggs in fast-flowing, clean, well-oxygenated water, the source of the vector will be limited to certain locations in the rivers, primarily the rapids. Thus, drone-guided breeding site mapping accompanied by trained entomologists will be needed to walk along accessible river banks, checking the trailing vegetation in the fast-flowing stretches of river for black fly larvae. The use of high-resolution drone-based images of *Simulium* breeding sites will rapidly cover relatively large areas in a short period of time. New technologies (drone-based mapping and possibly drone larvicide delivery) have been proposed for the Mahenge focus to map the inaccessible breeding sites and improve the precision of larviciding operations (Mushi, 2023). Although the approach is promising, further steps should be taken to make this pilot-stage a reality for *Simulium* control in Mahenge. Based on the evidence above, vector-targeted intervention combined with CDTI is feasible for the Mahenge focus.

Gaps and challenges: Scarcity of recent, peer-reviewed field trials of larviciding specifically in Mahenge (most literature is descriptive, entomological, modelling, or program letters); program reports and operational data are unevenly available (Mushi 2023).

Limitations of review: This study obtained a limited number of peer-reviewed intervention trials conducted specifically field trial of combined CDTI and vector control. Thus, reliance on program reports and modelling necessitates cautious interpretation.

Programmatic recommendations for Mahenge foci:

1. To conduct an up-to-date breeding-site mapping (both ground surveys and drone-assisted mapping, where terrain limits ground access). Pilot studies of combined targeted ground larviciding with intensified CDTI in Mahenge to reduce Annual Bitting Rates and interrupt onchocerciasis transmission. Priority should be given to hotspot villages where seroprevalence in children is high.
2. Chemical larvicide has a number of harmful effects; the study recommends the use of environmentally friendly larvicides such as (Bti/Bs) and environmental management. In case chemical use is required (e.g., temephos), validation for susceptibility testing and regulatory clearance will be required before organophosphates can be applied in large-scale.
3. Entomological surveillance systems, including breeding site mapping, larval density monitoring, adult biting collections and fly infection rates, need to be strengthened for programme monitoring (MDA uptake monitoring) and community engagement. This study proposes the use of modern technologies such as drones, GPS, and remote sensing to map breeding sites in the Mahenge ecosystem and validate with ground-truthing.
4. To ensure sustained control, there is a need to enhance the capacity of the entomology field teams. Since vector control is resource-intensive, it requires trained entomology teams and funding availability. Thus, training of staff and mobilisation of funds should be prioritised to ensure the sustainability of a proposed targeted *Simulium* vector control intervention.

5. Conclusions

Targeting *Simulium* vectors is both feasible and scientifically justified for the Mahenge focus. Available evidence, mainly combining historical entomology, programmatic experiences in Tanzania and modelling, supports the conclusion that vector-targeted interventions, principally larviciding guided by high-resolution breeding-site mapping and sustained surveillance, can accelerate control of onchocerciasis in Mahenge. Evidence from Africa shows that larviciding (using temephos or *Bti*), environmental management (through slash and clear) can dramatically reduce transmission in persistent onchocerciasis hotspots that remain despite long-term CDTI intervention. Therefore, well-designed operational pilots that combine CDTI, accurate mapping, surveillance, appropriate larvicidal choice after susceptibility testing, environmental management, community engagement and sustained funding, offer the highest probability of achieving onchocerciasis elimination in Mahenge.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

References

Basáñez, M. G., Walker, M., Turner, H. C., Coffeng, L. E., de Vlas, S. J., & Stolk, W. A. (2016). River blindness: Mathematical models for control and elimination. *Advances in Parasitology*, 94, 247–341.

Bhattacharyya, S., Vinkeles Melchers, N. V. S., Siewe Fodjo, J. N., Vutha, A., Coffeng, L. E., Logora, M. Y., et al. (2023). Onchocerciasis-associated epilepsy in Maridi, South Sudan: Modelling and exploring the impact of control measures against river blindness. *PLoS Neglected Tropical Diseases, 17*(5), e0011320.

Bhwana, D., Mmbando, B. P., Dekker, M. C., Mnacho, M., Kakorozya, A., & Matuja, W. (2019). Clinical presentation of epilepsy in six villages in an onchocerciasis endemic area in Mahenge, Tanzania. *Epileptic Disorders, 21*(5), 425–435.

Bhwana, D., Mmbando, B. P., Dusabimana, A., Mhina, A., Challe, D. P., & Siewe Fodjo, J. N., et al. (2022). Ivermectin treatment response in two rural villages with a high prevalence of onchocerciasis and epilepsy, Mahenge, Tanzania. *African Health Sciences, 22*(3), 607–616.

Boatin, B. A., & Richards, F. O. (2006). Control of onchocerciasis. In *[Book title not provided]* (pp. 349–394).

Cambra-Pellejà, M., Gandasegui, J., Balaña-Fouce, R., Muñoz, J., & Martínez-Valladares, M. (2020). Zoonotic implications of *Onchocerca* species on human health. *Pathogens, 9*(9), 761.

Cheke, R. A., Fiasorgbor, G. K., Walsh, J. F., & Yameogo, L. (2008). Elimination of the Djodji form of the blackfly *Simulium sanctipauli* sensu stricto as a result of larviciding by the WHO Onchocerciasis Control Programme in West Africa. *Medical and Veterinary Entomology, 22*(2), 172–174.

Colebunders, R., Stolk, W. A., Siewe Fodjo, J. N., Mackenzie, C. D., & Hopkins, A. (2019). Elimination of onchocerciasis in Africa by 2025: An ambitious target requires ambitious interventions. *Infectious Diseases of Poverty, 8*(1), 83.

Crump, A., Morel, C. M., & Omura, S. (2012). The onchocerciasis chronicle: From the beginning to the end? *Trends in Parasitology, 28*(7), 280–288.

de Moor, F. C., & Car, M. (1986). A field evaluation of *Bacillus thuringiensis* var. *israelensis* as a biological control agent for *Simulium chutteri* (Diptera: Nematocera) in the middle Orange River. *Onderstepoort Journal of Veterinary Research*, 53(1), 43–50.

Garms, R., Lakwo, T. L., Ndyomugyenyi, R., Kipp, W., Rubaale, T., Tukesiga, E., et al. (2009). The elimination of the vector *Simulium neavei* from the Itwara onchocerciasis focus in Uganda by ground larviciding. *Acta Tropica*, 111(3), 203–210.

Greter, H., Mmbando, B., Makunde, W., Mnacho, M., Matuja, W., Kakorozya, A., et al. (2018). Evolution of epilepsy prevalence and incidence in a Tanzanian area endemic for onchocerciasis and the potential impact of community-directed treatment with ivermectin: A cross-sectional study and comparison over 28 years. *BMJ Open, 8*(3), e017188.

Häusermann, W. (1969). On the biology of *Simulium damnosum* Theoblad, 1903, the main vector of onchocerciasis in the Mahenge mountains, Ulanga, Tanzania. *Acta Tropica, 26*(1), 29–69.

Hendy, A., Krüger, A., Pfarr, K., De Witte, J., Kibweja, A., Mwingira, U., et al. (2018). The blackfly vectors and transmission of *Onchocerca volvulus* in Mahenge, south eastern Tanzania. *Acta Tropica, 181*, 50–59.

Higazi, T. B., Zarroug, I. M. A., Mohamed, H. A., ElMubark, W. A., Deran, T. C. M., Aziz, N., et al. (2013). Interruption of *Onchocerca volvulus* transmission in the Abu Hamed focus, Sudan. *American Journal of Tropical Medicine and Hygiene*, 89(1), 51–57.

Jacob, B. G., Loum, D., Lakwo, T. L., Katholi, C. R., Habomugisha, P., Byamukama, E., et al. (2018). Community-directed vector control to supplement mass drug distribution for onchocerciasis elimination in the Madi mid-North focus of Northern Uganda. *PLoS Neglected Tropical Diseases*, 12(8), e0006702.

Jacob, B., Loum, D., Munu, D., Lakwo, T., Byamukama, E., Habomugisha, P., et al. (2021). Optimization of slash and clear community-directed control of *Simulium* *damnosum* sensu stricto in Northern Uganda. *American Journal of Tropical Medicine and Hygiene*, 104(4), 1394–1403.

Jacob, B., Michael, E., & Unnasch, T. R. (2024). Community-directed vector control to accelerate onchocerciasis elimination. *Pathogens*, 13(3).

Kalinga, A. K., Mweya, C. N., Barro, T., & Maegga, B. T. (2007). Susceptibility of *Simulium damnosum* complex larvae to temephos in the Tukuyu onchocerciasis focus, southwest Tanzania. *Tanzania Journal of Health Research, 9*(1).

Kamtsap, P., Archile, P., Flore, N., Njiokou, F., & Renz, A. (2023). Testing the susceptibility of larval stages of *Simulium* to temephos and *Bacillus thuringiensis* var. *israelensis* in Germany and Northern Cameroon. *Medical and Veterinary Entomology*, 37(2), 286–299.

Kleinerman, G., Eshed, T., Nachum-Biala, Y., King, R., & Baneth, G. (2021). Transmission of the human relapsing fever spirochete *Borrelia persica* by the argasid tick *Ornithodoros tholozani* involves blood meals from wildlife animal reservoirs and mainly transstadial transfer. *Applied and Environmental Microbiology, 87*(11).

Krüger, A., Car, M., & Maegga, B. T. A. (2005). Descriptions of members of the *Simulium damnosum* complex (Diptera: Simuliidae) from southern Africa, Ethiopia and Tanzania. *Annals of Tropical Medicine and Parasitology, 99*(3), 293–306.

Lacey, L. A., Escaffre, H., Philippon, B., Sékétéli, A., & Guillet, P. (1982). Large river treatment with *Bacillus thuringiensis* (H-14) for the control of *Simulium damnosum* s.l. in the Onchocerciasis Control Programme. *Tropical Medicine and Parasitology*, 33(2), 97–101.

Lakwo, T. L., Ndyomugyenyi, R., Onapa, A. W., & Twebaze, C. (2006). Transmission of *Onchocerca volvulus* and prospects for the elimination of its vector, the blackfly *Simulium neavei* in the Mpamba-Nkusi focus in Western Uganda. *Medical and Veterinary Entomology*, 20(1), 93–101.

Lakwo, T., Garms, R., Wamani, J., Tukahebwa, E. M., Byamukama, E., Onapa, A. W., et al. (2017). Interruption of the transmission of *Onchocerca volvulus* in the Kashoya-Kitomi focus, western Uganda by long-term ivermectin treatment and elimination of the vector *Simulium neavei* by larviciding. *Acta Tropica*, 167, 128–136.

Maegga, B. T., et al. (2018). *The vector elimination programme and subsequent recrudescence of the vector population in the Tukuyu focus of onchocerciasis in Tanzania* (Program report/unpublished). Dar es Salaam.

McMahon, J. P., Highton, R. B., & Goiny, H. (1958). The eradication of *Simulium neavei* from Kenya. *Bulletin of the World Health Organization*, 19(1), 75–107.

Merritt, R. W., Walker, E. D., Wilzbach, M. A., Cummins, K. W., & Morgan, W. T. (1989). A broad evaluation of *Bacillus thuringiensis* var. *israelensis* for black fly (Diptera: Simuliidae) control in a Michigan river: Efficacy, carry and nontarget effects on invertebrates and fish. *Journal of the American Mosquito Control Association*, 5(3), 397–415.

Ministry of Health. (2023). *Integrated vector management guidelines and standard operating procedures*. Dar es Salaam.

Mmbando, B. P., Suykerbuyk, P., Mnacho, M., Kakorozya, A., Matuja, W., Hendy, A., et al. (2018). High prevalence of epilepsy in two rural onchocerciasis endemic villages in the Mahenge area, Tanzania, after 20 years of community-directed treatment with ivermectin. *Infectious Diseases of Poverty, 7*(1), 64.

Mushi, V. (2018). *Factors associated with persistence of onchocerciasis transmission after two decades of community-directed treatment with ivermectin in Ulanga District Council*. Sokoine University, Morogoro.

Mushi, V. (2023). *Simulium* surveillance and control in Mahenge, Tanzania: Time to think bigger and utilize drone-based remote sensing technology. *Bulletin of the National Research Centre, 47*(1), 38.

Mushi, V. P., Bhwana, D., Massawe, I. S., Makunde, W., Sebukoto, H., Ngasa, W., et al. (2024). Prevalence of onchocerciasis and epilepsy in a Tanzanian region after a prolonged community-directed treatment with ivermectin. *PLoS Neglected Tropical Diseases, 18*(9), e0012470.

Olanrewaju, T. O., Enwezor, F. N. C., Lar, L. A., Igbe, M. A., Abdullahi, R. A., Adeleke, M. A., et al. (2025). Recrudescence of transmission of onchocerciasis in some endemic communities in Kaduna State, Nigeria: What is the way forward? *PLoS Neglected Tropical Diseases*, 19(8), e0012495.

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al.

(2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ*, n160.

Plaisier, A. P., Alley, E. S., van Oortmarssen, G. J., Boatin, B. A., & Habbema, J. D. (1997). Required duration of combined annual ivermectin treatment and vector control in the Onchocerciasis Control Programme in West Africa. *Bulletin of the World Health Organization*, 75(3), 237–245.

Raimon, S., Lakwo, T. L., Sebit, W. J., Siewe Fodjo, J. N., Alinda, P., Carter, J. Y., et al. (2021). “Slash and clear”, a community-based vector control method to reduce onchocerciasis transmission by *Simulium sirbanum* in Maridi, South Sudan: A prospective study. *Pathogens*, 10(10), 1329.

Routledge, I., Walker, M., Cheke, R. A., Bhatt, S., Nkot, P. B., Matthews, G. A., et al. (2018). Modelling the impact of larviciding on the population dynamics and biting rates of *Simulium damnosum* (s.l.): Implications for vector control as a complementary strategy for onchocerciasis elimination in Africa. *Parasites & Vectors*, 11(1), 316.

Schwan, T. G., Anderson, J. M., Lopez, J. E., Fischer, R. J., Raffel, S. J., McCoy, B. N., et al. (2012). Endemic foci of the tick-borne relapsing fever spirochete *Borrelia crocidurae* in Mali, West Africa, and the potential for human infection. *PLoS Neglected Tropical Diseases*, 6(11), e1924.

Smith, M. E., Bilal, S., Lakwo, T. L., Habomugisha, P., Tukahebwa, E., Byamukama, E., et al. (2019). Accelerating river blindness elimination by supplementing MDA with a vegetation “slash and clear” vector control strategy: A data-driven modeling analysis. *Scientific Reports*, 9(1), 15274.

Traoré, S., Wilson, M. D., Sima, A., Barro, T., Diallo, A., Aké, A., et al. (2009). The elimination of the onchocerciasis vector from the island of Bioko as a result of larviciding by the WHO African Programme for Onchocerciasis Control. *Acta Tropica*, 111(3), 211–218.

Vinkeles Melchers, N. V. S., Agoro, S., Togbey, K., Padjoudoum, K., Telou, I. G., Karabou, P., et al. (2024). Impact of ivermectin and vector control on onchocerciasis transmission in Togo: Assessing the empirical evidence on trends in infection and entomological indicators. *PLoS Neglected Tropical Diseases*, 18(7), e0012312.

World Health Organization. (2016). *Guidelines for onchocerciasis control*. Geneva.

World Health Organization. (2025, January). *Onchocerciasis*. Geneva.

Zarroug, I. M. A., Hashim, K., ElMubark, W. A., Shumo, Z. A. I., Salih, K. A. M., ElNojomi, N. A. A., et al. (2016). The first confirmed elimination of an onchocerciasis focus in Africa: Abu Hamed, Sudan. *American Journal of Tropical Medicine and Hygiene*, 95(5), 1037–1040.

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