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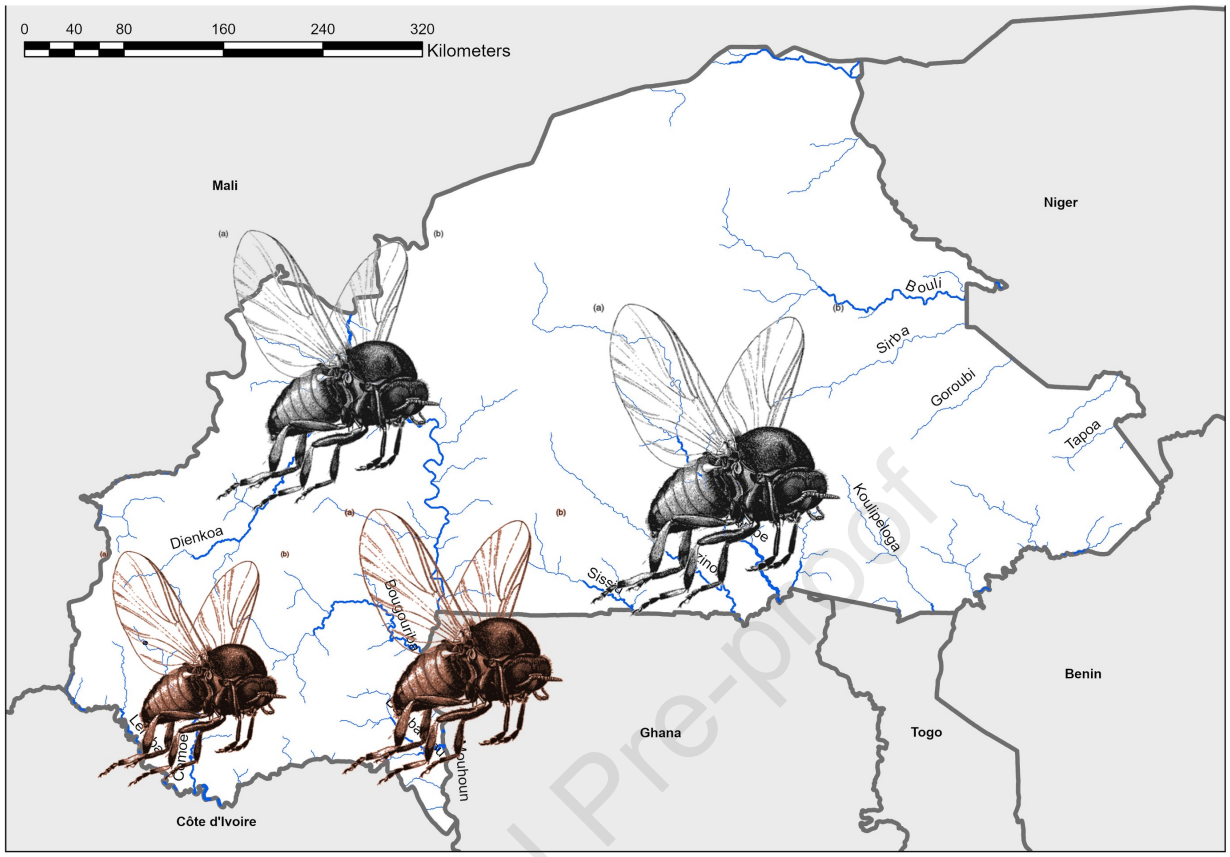
CRediT authorship contribution statement

Lassane Koala: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Supervision, Visualization, Formal analysis, Data curation. **Achille S. Nikièma:** Investigation, Writing – review & editing. **Mathias Ouedraogo:** Investigation, Writing – review & editing. **Justin Compaoré:** Conceptualization, Investigation, Methodology, Funding acquisition, Writing – review & editing. **Clarisse Bougouma:** Funding acquisition, Writing – review & editing. **Karim Sanon:** Investigation, Writing – review & editing. **Aimé G. Adjami:** Investigation, Writing – review & editing, Formal analysis. **Moussa S. Sanfo:** Investigation, Writing – review & editing. **Soungalo Traore:** Conceptualization, Investigation, Methodology, Funding acquisition, Writing – review & editing. **Inaki Tirados:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Philip McCall:** Writing – review & editing, Visualization. **Paul Bessell:** Writing – review & editing, Formal analysis. **Thomas R. Unnasch:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Daniel A. Boakye:** Writing – review & editing, Visualization. **Roch K. Dabire:** Writing – review & editing, Data curation.



Entomological surveillance of onchocerciasis in Burkina Faso: Progress towards interrupting transmission in blackflies in the main river basins of the country

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ABSTRACT

Current guidelines for onchocerciasis elimination rely heavily upon assessment of the presence of *Onchocerca volvulus* in the vector *Simulium damnosum* (*sensu lato*). This entomological study was conducted over four years in several regions of Burkina Faso to determine the progress made towards interrupting onchocerciasis transmission. Larvae and adult blackflies were collected in eight river basins (Comoé, Léraba, Dienkoa, Mouhoun, Bougouriba,

Bambassou, Nakambé, Nazinon and Sissili). Larvae were analysed by cytotaxonomy, and the adult blackflies analysed for the presence of infective larvae of *O. volvulus* by PCR. Blackfly infectivity rates were first determined by year for each basin, then compared to the thresholds established by the WHO. The results indicate that the blackflies collected belong to the savannah group *Simulium damnosum* (*sensu stricto*) and *Simulium sirbanum*. Hybrids of the two species were also identified. Overall, the prevalence of flies carrying infective larvae was below the threshold of 0.05% established by the WHO indicating important progress towards the interruption of onchocerciasis transmission in Burkina Faso, though hotspots with infectivity rates well above the WHO's thresholds remain. *Onchocerca volvulus* continues to be transmitted in six of the nine basins evaluated, all of which border neighbouring countries. These data indicate that it will be necessary to maintain entomological surveillance in these hotspot areas until transmission is interrupted throughout the region.

Keywords: Onchocerciasis; Transmission; *Simulium*; Surveillance; Persitence,

1. Introduction

Onchocerciasis is a neglected tropical disease caused by the nematode worm *Onchocerca volvulus.* This parasite is responsible, in humans, for dermal and ocular manifestations that can lead to blindness (WHO, 2016). *Onchocerca volvulus* is transmitted to humans by the bite of *Simulium* flies, small, biting flies that generally breed in fast-flowing rivers (Le Berre, 1966). In Africa, the major vectors of onchocerciasis are members of the *Simulium damnosum* species complex. Onchocerciasis is one of the neglected tropical diseases for which preventive chemotherapy with ivermectin is available (WHO, 2016). Ivermectin is administered in community-based mass distribution campaigns known as Community Directed Treatment with Ivermectin (CDTI). Currently, the World Health Organization has set a goal of the elimination of onchocerciasis in Africa, employing CDTI as the main strategy to achieve elimination (WHO, 2020).

Burkina Faso is a formerly onchocerciasis hyperendemic country where the disease was a severe public health problem before the advent of the Onchocerciasis Control Programme (OCP) in 1974 (Boatin et al., 1997). The control efforts of the OCP and national programmes in the endemic countries have eliminated onchocerciasis as a public health problem in Burkina Faso and 10 other endemic countries in West Africa (Thylefors and Alleman, 2006). Following the OCP's closure in 2002, OCP recommended to the National Onchocerciasis Control Programme of Burkina Faso (now the National Programme for the Control of Neglected Tropical Diseases

(PNMTN)), that they continue regular entomological and epidemiological surveillance of the disease in sentinel villages located in the country's endemic river basins. In response to this recommendation, the PNMTN conducted surveillance activities in 2003, 2005, 2007/2008, 2009, and 2010/2011 in sentinel villages and capture points along the main rivers of the country (namely the Oti-Pendjari, Kompienga, Léraba, Mouhoun, Dienkoa, Bougouriba, Comoé), and the tributary of the Comoé, the Koflandié (Koala et al., 2017; Nikièma et al., 2018). The results of the epidemiological surveys, carried out with skin snips, were generally satisfactory with prevalences under 5% while entomological surveillance indices were under the thresholds established by the WHO guidelines. However, in 2007 and 2008, higher than expected prevalences began to be observed along the Comoé River Basin in the Cascades Region. This trend was confirmed in 2010–2011 with a recrudescence of onchocerciasis along the Comoé River Basin (Koala et al., 2017, 2019). The recrudescence in the Cascades Region led to a series of interventions by the PNMTN and its partners, including the introduction of CDTI in the Cascades Region in 2011 and in the South-West Region in 2013, where transmission recrudescence had also been detected along the Mouhoun and Bougouriba rivers in 2010/2011 (Nikièma et al., 2024).

Currently, onchocerciasis is endemic in two health regions of Burkina Faso, the Cascades and the South-West regions, where CDTI interventions are ongoing. The presence of major rivers, including the Comoé, Léraba, and Mouhoun, which contain breeding habitats for the vector blackflies and where both human and blackfly migration occurs, contributes to the endemicity of onchocerciasis in these regions. Fortunately, ongoing CDTI has contributed to the reduction of onchocerciasis transmission in these regions, as the results of the latest epidemiological assessments conducted in the South-West Region have shown prevalences ranging from 0.41% to 3.54%, below the WHO thresholds (Nikièma et al., 2024).

However, in the current context of disease elimination, it is important to assess the situation of parasite transmission not only in vectors present in the river basins of currently endemic regions but also in the river basins of regions which were formerly endemic for the disease. Indeed, the WHO recommends regularly evaluating progress towards interrupting transmission by the O-150 PCR method in blackflies collected in different transmission zones (WHO and APOC, 2010; WHO, 2016). This is essential for determining whether to cease CDTI in areas currently under treatment and to validate the current non-endemic status of regions where CDTI has not been implemented. In recent years, the PNMTN and its partners have conducted entomological assessments at *S. damnosum* (*sensu lato*) breeding habitats located near the main river basins in both the endemic and non-endemic regions of Burkina Faso. The

primary objective of this study was to verify the status of *O. volvulus* transmission among disease vectors present in endemic and non-endemic regions of Burkina Faso.

2. Materials and methods

2.1. Description of the study sites

This study was conducted from July to December in the years 2017, 2018, 2019 and 2021 across various onchocerciasis-endemic basins in Burkina Faso (activities were not carried out in 2020 due to the COVID-19 pandemic). The *Simulium* spp. capture points were strategically distributed along nine endemic basins spanning six administrative regions of the country. These regions include the Cascades Region with Comoé and Léraba river basins, the Hauts-Bassins Region with the Dienkoa River basin, the South-West Region with the Mouhoun, Bougouriba and Bambassou river basins, the Centre-West Region with the Sissili River basin, Centre-South Region with Nazinon River basin and the Centre-East Region with the Nakambé River basin. The locations of the river basins are shown in Fig. 1.

The climate in the study areas is characteristic of the West Sudanian Savannah Ecoregion, with a dry season extending from November to April and a rainy season from May to October. The average rainfall in these regions exceeds 900 mm, with temperatures ranging between 17 °C and 36 °C. Historically, all study sites were hyper-endemic for onchocerciasis, and all were included in the OCP coverage area (Boatin et al., 2008). Currently, only the Cascades and South-West regions remain under CDTI (Koala et al., 2017; Nikièma et al., 2024). However, other regions have also undergone treatment with ivermectin and albendazole for lymphatic filariasis. Recent data indicate residual onchocerciasis transmission in several of these basins, partially attributed to human migration (Nikièma et al., 2018).

The primary vectors of onchocerciasis in these areas are *Simulium damnosum* (*sensu stricto*) and *Simulium sirbanum.* In the Sudanian Savannah Ecoregion, *S. damnosum* (*s.s.*) is predominantly active during the dry season while *S. sirbanum* is more prevalent during the rainy season (Boakye et al., 1998; Koala et al., 2019).

2.2. Choice of basins and selection of *Simulium* spp. capture points

Vector capture points were strategically selected along river basins where recent and former epidemiological assessments indicated onchocerciasis endemicity. These capture points were located near the blackfly breeding habitats of the nine endemic rivers, i.e. Léraba, Comoé,

Dienkoa, Mouhoun, Bougouriba, Bambassou, Nazinon, Nakambé and Sissili (Fig. 2). Over the study period, entomological surveillance activities were conducted at 9 points in 2017, 22 points in 2018, 28 points in 2019 and 18 points in 2021.

2.3. Larval site surveys and cytotaxonomic analyses

From July to December 2019 and 2021 monthly larval surveys were conducted at accessible breeding sites within the study area. *Simulium* spp. larvae and pupae were collected from plant and rocky substrates, as recommended by the WHO (2023). Collected specimens were preserved in either 80% alcohol or Carnoy's solution (3:1 ethanol: glacial acetic acid). Larval samples preserved in Carnoy's solution underwent cytotaxonomic analyses following the methodology of Boakye and Meredith (1993) to identify the cytospecies of the *Simulium damnosum* complex.

The larvae were processed by first opening the abdomen, then washing and blotting them on filter paper. The larvae were subsequently stained with lacto-acetic orcein and kept in the dark for three hours. Chromosomes were then extracted under a stereomicroscope and mounted on glass slides. The chromosomes were spread between the glass slide and the coverslip by gentle pressure. The prepared chromosomes were then examined under a compound microscope and chromosomal inversions were identified by comparison with the standard maps, provided by Boakye and Meredith (1993).

2.4. Capture and identification of adults of *Simulium* spp.

Adults of *Simulium* spp. were collected using the Human Landing Capture method (HLC) following the WHO protocols (WHO, 2023). HLCs were conducted from 7:00 h to 18:00 h on designated days each month, from July to December over four years, ending in January 2021. Collected blackflies were preserved in 80% alcohol and transferred to the ESPEN Reference Laboratory for morphological identification and further molecular analysis. Morphological identification was performed to distinguish *Simulium damnosum* (*s.l.*) from other species using the criteria described by Davies et al. (1991). Specific morphological features such as wing tufts, procoxa, antennae and scutal tufts were also used to differentiate savannah cytospecies (*S. damnosum* (*s.s.*) and *S. sirbanum*) from other cytospecies (Davies et al., 1991; WHO, 2023).

2.5. Molecular analysis and entomological indicators of transmission

Isolated heads of adult specimens of *Simulium* spp. collected from each capture point were analysed for infectivity using the poolscreen O-150 PCR technique (Katholi et al., 1995; Unnasch and Meredith, 1996; Yaméogo et al., 1999). Evidence for infectious stages of *O. volvulus* was obtained by testing for the presence of parasite DNA in pools of *Simulium* spp. heads using the polymerase chain reaction (PCR) technique and *O. volvulus*-specific DNA probes targeting the O-150 family of repeat sequences. Pool screen software was used to estimate infectivity rates with an associated 95% confidence interval (CI) (Katholi et al., 1995). The WHO specifies that the critical threshold for interruption or elimination of transmission is an upper limit of the 95% CI for the point estimate of the prevalence of blackflies carrying infective larvae that excludes 0.05%, which represents less than 1 infectious blackfly per 2000 individuals (WHO, 2016).

3. Results

3.1. Larval surveys

In 2019, larval surveys and cytotaxonomic identifications of collected larvae were conducted at six capture points located in the villages of Koregnon-Naimo and Bapla on the Bougouriba River, Zambo on the Mouhoun River and Bodadiougou on the Comoé River (Fig. 1). In 2021, larval surveys focused on four capture points in the village of Bodadiougou, all situated along the Comoé River. Other potential sites were either flooded or inaccessible during the survey period. All surveyed breeding sites were positive for the aquatic stages of *S. damnosum* (*s.l.*). Analyses of the salivary chromosomes of 211 larvae of *S. damnosum* (*s.l.*) collected in 2019 revealed that they all belonged to the savannah sibling species of this complex In this collection, 196 were identified as *Simulium sirbanum*, 5 were identified as *S. damnosum* (*s.s.*), and 10 were hybrids of the two species. In 2021, out of 52 larvae collected, 51 were *Simulium sirbanum* while only 1 *Simulium damnosum* (*s.s.*) larva was collected. The species distribution for the 2019 and 2021 collections are summarized in Table 1.

3.2. Adult female captures and infectivity rates

All captured blackflies were morphologically identified as belonging to the *S. damnosum/S. sirbanum* savannah group. Molecular analyses of the captured flies allowed us to determine the infectivity rates. The capture points where *O. volvulus* was identified are summarized in Fig. 3.

3.2.1. Léraba River Basin

A total of four capture points were assessed along the Léraba River in 2017, and three capture points were assessed in 2018, 2019, and 2021. Totals of 3680, 5271, 5766 and 6479 blackflies were collected in 2017, 2018, 2019 and 2021, respectively (Table 2). No infections were found in black flies collected in 2018 and 2019. The molecular analyses indicated the presence of *O. volvulus* infective larvae at the Pont Léraba border capture point in 2017 (four positive pools) and 2021 (three positive pools). The overall infective rates were estimated in 0.122% in 2017, nil in 2018 and 2019, and 0.051% in 2021.

3.2.2. Comoé River Basin

The results of the analyses conducted at the collection sites along the Comoé River are summarized in Table 3. In 2019, entomological surveys were carried out at three capture points, specifically in Bodiadougou village along the Comoé River. A total of 17,794 blackflies were captured and molecularly analysed revealing no infective flies. In 2021, 15 capture points were monitored along the Comoé River. A total of 40,931 blackflies were collected from July to December along this river basin. *Onchocerca volvulus* DNA in isolated fly heads was detected at three capture points giving a global infectivity rate of 0.022%. Of the 9 positive pools detected, 7 were from a single capture point (Bodadiougou Peulh; Table 3)

3.2.3. Dienkoa River Basin

The results from the surveys conducted along the Diekoa River are summarized in Table 4. Three capture points were monitored in the Dienkoa River Basin. The total number of flies collected was 529 in 2017, 3869 in 2018 and 1746 in 2019. No flies carrying *O. volvulus* infective larvae were detected at these sites in any of the three years (Table 4).

3.2.4. Bougouriba River Basin

The results of the surveys in the Bougouriba River are summarized in Table 5. Surveys were conducted at 6 capture points in this basin in 2018 and at 7 capture points in 2019. Totals of 44,398 blackflies and 27,328 were captured in 2018 and 2019, respectively. All these blackflies were morphologically identified as belonging to the savannah group *S. damnosum* (*s.s.*)*/S. sirbanum.* In 2018, molecular analyses revealed a single positive pool collected at the Koregnon capture point. The overall infectivity rate was 0.002% in the 44,398 blackflies captured in this basin in 2018. No infections were found in the 27,328 blackflies captured in this basin in 2019.

3.2.5. Mouhoun River Basin

The survey results from the Mouhoun River Basin are summarized in Table 6. Six capture points were monitored in 2018 and 8 capture points in 2019. A total of 35,398 blackflies were captured in 2018 and 14,180 blackflies were captured in 2019 from July to December. Molecular analyses detected *O. volvulus* DNA in three pools of *Simulium* spp. flies collected at the border capture points of Djonbal, Manoa, and Maregnawa. The infectivity rate was 0.0085% in 2018. In 2019, the molecular analyses of the 14,180 blackflies collected revealed no positive pools.

3.2.6. Bambassou River Basin

In this basin, a single capture point of Bambassou was assessed (Table 7). A total of 9133 blackflies were captured in 2018 compared to 1591 in 2019. Molecular results indicated the presence of *O. volvulus* DNA in fly heads with one positive pool in each of the 2018 and 2019 collections. Infectivity rates were 0.013% and 0.074% in 2018 and 2019, respectively.

3.2.7. Nazinon, Nakambé, and Sissili Basins

In the Nakambé River Basin, the Loaba capture point was monitored for three consecutive years, collecting 1009, 870, and 88 flies in 2017, 2018, and 2019, respectively. Infectivity rates for this capture point were zero each year, with upper limits of confidence intervals above 0.05% (Table 8).

In the Nazinon River Basin, the Ziou capture point was monitored in 2017 and 2019, collecting 2007 and 42 blackflies, respectively. *Onchocerca volvulus* was detected in 2017 with an infectivity rate of 0.052% while the rate was zero in 2019. The Sissili capture point on the Sissili River Basin was monitored in 2017 and 2018 with 104 and 1573 blackflies collected, respectively. Infectivity rates were zero in both years.

4. Discussion

Cytotaxonomic analyses identified the savannah group species *S. damnosum* (*s.s.*) and *S. sirbanum*, confirming their role as main onchocerciasis vectors in Burkina Faso. Most larvae collected were identified as *S. sirbanum*. Our results are consistent with those of Boakye (1998), who reported *S. sirbanum* as the dominant species during the rainy season, with *S. damnosum* (*s.s.*) prevailing during the dry season. Both species are competent vectors of *O. volvulus* (Cheke and Garms, 2013). Savanna group species of *Simulium* are proficient vectors of *O. volvulus* and

their abundance in the sites surveyed suggests a potential risk for active transmission (Cheke and Garms, 2013).

There was a large variation in the number of flies collected in each river basin from year to year. Environmental and climatic variations combined with anthropogenic modifications of *Simulium* spp. breeding sites probably affected blackfly population dynamics. The irregularity of rainfall influences the productivity of breeding sites, sometimes limiting the periods of abundance of blackflies to a few months, or even a few weeks, in some capture points. If these periods of high abundance are missed, it is difficult for the capture teams to collect the minimum required quantities of blackflies (n = 6000) for entomological survey of transmission. The WHO (2016) recommended "collecting as much as possible" flies in locations where it is difficult to obtain the minimum number of flies required. However, it would be desirable in the planning of future activities to consider the environmental and climatic variations influencing each basin when planning the times that capture activities are carried out.

In general, the results presented here suggest that onchocerciasis in Burkina Faso is well controlled and on the path towards elimination. However, it is apparent that hotspots of transmission remain in many of the river basins in the country. Infectivity rates for each river basin were equal to or lower than the threshold of 0.05%, which has been suggested by the WHO to represent the transmission breakpoint (WHO, 2016). However, *O. volvulus* is still circulating in some areas in the Cascades Region along the Comoé and Léraba River basins and in the Southwest Region along the Bambassou, Bougouriba and Mouhoun River basins, although both these regions have been under twice per year CDTI since 2011 and 2013. Moreover, infection was not detected in some locations, but the upper limit of the confidence interval was above the threshold established by the WHO. This was attributable to the low numbers of blackflies analysed at these sampling points (Katholi et al., 1995; Basañez et al., 1998). Consequently, the values of the confidence intervals in those points just give an indication of transmission but do not allow a definitive conclusion as to any interruption or maintenance of transmission in these basins.

The Burkina Faso NTD programme and its partners recently delineated the country into six operational transmission zones each of which is thought to represent a distinct ecological unit of parasite transmission (PNMTN, 2022, unpublished). From this new delineation, the Mouhoun, the Bougouriba and the Bambassou River basins form a single transmission zone. The regions bordering the Comoé River and its main tributary the Léraba River were defined as second transmission zone, while the regions bordering the Nakambé, Nazinon and Sissili River basins were defined as a third transmission zone. The areas bordering the Dienkoa River were defined as a fourth zone. However, when analysing the data in the context of these new delineations of

transmission zones, our findings still suggest that onchocerciasis transmission appears to be controlled and good progress towards elimination is being made.

Despite the good overall progress being made by Burkina Faso towards the elimination of onchocerciasis, it is clear from the data above that hotspots of transmission still exist. For example, a total of 9 positive pools were observed in the flies collected in the Comoé River Basin in 2021. Of these, 7 (of a total of 52 total pools) were from a single collection point (Bodadiougou Peulh). There are several possible reasons for the persistence of transmission at certain sites. First, Burkina Faso historically has been hyperendemic for onchocerciasis, and during the period of recrudescence in the Cascades and South-West regions, onchocerciasis prevalences reached 70% in some villages (Koala et al., 2017, 2019; Nikièma et al., 2024). It is known that high baseline prevalence increases the time required for the interruption of onchocerciasis transmission (WHO and APOC, 2010; WHO, 2016). The high baseline prevalences may explain the persistence of infection in these regions after nearly 10 years of CDTI. Secondly, it is known that high vector densities, resulting in high biting rates in the population, are an important driver in determining the intensity of *O. volvulus* transmission (Lamberton et al., 2015). In some cases, anthropogenic changes have increased vector densities and biting rates. For example, the dam on the Comoé River resulted in the development of a large breeding stie downstream of the dam that is active year-round. A third reason for the presence of hotspots may be due to re-invasion of infectious flies. The Léraba River Basin has been known to be subject to blackfly reinvasion since the time of the OCP (Garms, 1981) and recently Koala et al. (2019) hypothesized that reinvasion of certain points along the Comoé River might explain the finding of *S. damnosum* (*s.l.*) adults with very high parity rates while the local breeding sites were almost completely non-productive. Finally, some of the persistent hotspots may be due to extension of a transmission zone into neighboring countries. Most collection points where infective flies were found are located on the borders with Ghana and Ivory Coast, two countries endemic for onchocerciasis with which Burkina shares river basins such as the Comoé and the Mouhoun. It is possible that infections present in the neighboring countries might result in cross-border migration of either infected flies or infected people, resulting in evidence of ongoing transmission in Burkina Faso.

5. Conclusions

The results of our study indicate that Burkina Faso has made significant progress towards interrupting transmission in several endemic basins. The transmission of onchocerciasis has been globally controlled in all the basins investigated, either through repeated CDTI rounds or

because of a decrease in *S. damnosum* (*s.l.*) densities. However, residual transmission remains at hotspots in many basins. This is especially concerning because almost all the capture points where infective flies have been found are in areas bordering Ghana and Côte d'Ivoire. This represents a risk of onchocerciasis recrudescence in these areas. Entomological surveillance should, therefore, be maintained in all these basins until transmission is definitively interrupted. Additionally, it is imperative that transmission zones be delimited to facilitate surveillance of the disease within the country and in cross-border regions when transmission zones are found to extend into the neighbouring countries.

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Ethical approval

The Ethics Committee of the Ministry of Health of Burkina Faso approved all PNMTN activities related to disease control and elimination. As the activities were conducted as part of routine surveillance for an infectious disease by the public health authorities of Burkina Faso, the study was deemed as research not involving human subjects. Human landing collections were carried out by volunteers from the endemic communities. The activities were clearly explained in French and Dioula (the local language of the regions) to the volunteers who participated as HLCs. Capturers were thoroughly trained in vector capture techniques to minimize the risk of fly bites. No human samples were collected for diagnosis, and no treatments were administered as part of the study. However, all participants received ivermectin as part of the bi-annual CDTI campaigns conducted by the national program (PMTN) in the Cascades and South-West regions. In regions where CDTI was not implemented, participants received a single dose of ivermectin as a prophylactic measure.

CRediT authorship contribution statement

Lassane Koala: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Supervision, Visualization, Formal analysis, Data curation. **Achille S. Nikièma:** Investigation, Writing – review & editing. **Mathias Ouedraogo:** Investigation, Writing – review & editing. **Justin Compaoré:** Conceptualization, Investigation, Methodology, Funding acquisition, Writing – review & editing. **Clarisse Bougouma:** Funding acquisition, Writing – review & editing. **Karim Sanon:** Investigation, Writing – review & editing. **Aimé G. Adjami:** Investigation, Writing – review & editing, Formal analysis. **Moussa S. Sanfo:** Investigation, Writing – review & editing. **Soungalo Traore:** Conceptualization, Investigation, Methodology, Funding acquisition, Writing – review & editing. **Inaki Tirados:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Philip McCall:** Writing – review & editing, Visualization. **Paul Bessell:** Writing – review & editing, Formal analysis. **Thomas R. Unnasch:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Daniel A. Boakye:** Writing – review & editing, Visualization. **Roch K. Dabire:** Writing – review & editing, Data curation.

Data availability

The data supporting the conclusions of this article are included within the article.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the studies reported in this paper.

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Figure legends

Fig. 1. Distribution of onchocerciasis-endemic rivers in Burkina Faso. The solid lines represent the geographical boundaries of the countries.

Fig. 2. Distribution of *Simulium damnosum* (*s.l.*) capture points along the onchocerciasis-endemic river basins of Burkina Faso.

Fig. 3. Map representing the results of molecular analyses of blackflies captured during 2017, 2018, 2019 and 2021 along the nine monitored river basins. Red circles indicate the capture points where *O. volvulus* was found in the flies analysed; black circles indicate the capture points where *O. volvulus* was not found; empty circles indicate capture points where there was no survey in that year.

Table 1

Results of cytotaxonomic identifications of *Simulium* spp. larvae collected along the Comoé and Bougouriba rivers in 2019 and 2021.

Year	Breeding habitat	River	*N*	*S. damnosum* (*s.s*)	*S. sirbanum*	*S. damnosum s.s.* × *S. sirbanum* hybrids
2019	Niamo/Korégnon/B	Bougouriba	24	0	24	0
2019	Zambo	Mouhoun	41	1	39	1
2019	Bapla	Bougouriba	42	1	39	2
2019	Bodadiougou Barrière	Comoé	45	1	42	2
2019	Bodadiougou Chutes	Comoé	32	0	29	3
2019	Bodadiougou Peulh	Comoé	27	2	23	2
2021	Bodadiougou Petit Barrage	Comoé	16	0	16	0
2021	Bodadiougou Barrière	Comoé	16	1	15	0
2021	Bodadiougou Chutes	Comoé	14	0	14	0
2021	Bodadiougougou Peulh	Comoé	6	0	6	0
	Total		263	6	247	10

Abbreviation: *N*, number of samples analyzed.

Table 2

Onchocerciasis transmission along the Léraba River during 2017, 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2017	Loumana	214	1	0	0	0–0.900
2017	Pont Léraba	2723	9	4	0.204	0.050–0.536
2017	Bagera	1	1	0	0	0
2017	Douna	742	2	0	0	0 –0.464
Subtotal		3680	13	4	0.122	0.030–0.317
2018	Douna	95	1	0	0	0–0.637
2018	Loumana	5073	17	0	0	0–0.037
2018	Baguera	103	1	0	0	0–0.637
Subtotal		5271	19	0	0	0
2019	Loumana	3042	10	0	0	0–0.063
2019	Douna	125	1	0	0	0–1.524
2019	Pont Léraba	2599	9	0	0	0–0.071
Subtotal		5766	20	0	0	0
2021	Loumana	616	2	0	0	0–0.265
2021	Pont Léraba	5142	26	3	0.062	0.011–0.180
2021	Dagouindougou	721	3	0	0	0–0.265
Subtotal		6479	31	3	0.051	0.009–0.147

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

Table 3

Onchocerciasis transmission along the Comoé River during 2019 and 2021.

Year	Capture point	*N*	No of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2019	Bodadiougou Barriere	5474	19	0	0	0–0.037
2019	Bodadiougou Peulh	6340	21	0	0	0–0.030
2019	Bodadiougou Chutes	5980	20	0	0	0–0.310
Subtotal	Subtotal comoe river	17,794	60	0	0	0–0.010
2021	Bodadiougou Village	4308	22	0	0	0–0.044
2021	Bodadiougou Barriere	6106	31	1	0.016	0.005–0.085
2021	Bodadiougou Peulh	10,376	52	7	0.124	0.046–0.260
2021	Bodadiougou Petit Barrage	4192	21	0	0	0–0.045
2021	Kayouna	4702	24	0	0	0–0.039
2021	Gnerpien	5801	29	1	0.017	0–0.090
2021	Congala	1016	5	0	0	0–0.030
2021	Badara Folonzo	328	2	0	0	0–0.583
2021	Badara Boko	1799	9	0	0	0–0.106
2021	Badara Karaboro	735	4	0	0	0–0.260
2021	Bolibana	571	3	0	0	0–0.335
2021	Kossoumani	386	2	0	0	0–0.496
2021	Bandougou	148	1	0	0	0–1.288
2021	Toussiambougou	62	1	0	0	0–3.049
2021	Sakora 2	401	2	0	0	0–0.477
Subtotal		40,931	208	9	0.022	0.009–0.042

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

Table 4

Onchocerciasis transmission along the Dienkoa River during 2017, 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI
2017	Gossiamandara	22	1	0	0	0
2017	Lanviera Pont	507	2	0	0	0–0.319
Subtotal		529	3	0	0	0–0.213
2018	Samandeni	1030	4	0	0	0–0.159
2018	Badara	105	1	0	0	0–0.637
2018	Lanviera Pont	2734	9	0	0	0–0.071
Subtotal		3869	14	0	0	0–0.041
2019	Samandeni	509	2	0	0	0–0.319
2019	Guena Pont	32	1	0	0	0–5.823
2019	Djigouera	1205	4	0	0	0–0.159
Subtotal		1746	7	0	0	0–0.063

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

Table 5

Onchocerciasis transmission along the Bougouriba river during 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2018	Koregnon	7730	26	1	0.013	0.0004–0.067
2018	Wapassi	8599	29	0	0	0–0.022
2018	Lemania	6654	22	0	0	0–0.029
2018	Danko Tanzou	9702	32	0	0	0–0.019
2018	Bapla	5394	18	0	0	0–0.035
2018	Navrikpe	6319	21	0	0	0–0.304
Subtotal		44,398	148	1	0.002	0.0006–0.011
2019	Koregnon	1641	5	0	0	0–0.106
2019	Wappassi	1652	6	0	0	0–0.106
2019	Lemania	6596	22	0	0	0–0.029
2019	Danko Tanzou	5212	17	0	0	0–0.035
2019	Bapla	3562	12	0	0	0–0.053
2019	Navrikpe	2113	7	0	0	0–0.091
2019	Zambo	6552	22	0	0	0–0.029
Subtotal		27,328	91	0	0	0–0.007

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

Table 6

Onchocerciasis transmission along the Mouhoun River during 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2018	Manoa	6113	20	1	0.017	0.005–0.088
2018	Baho Ouessa	591	2	0	0	0–0.319
2018	Boukero	5650	19	0	0	0–0.033
2018	Maregnawa	6307	21	1	0.016	0.005–0.083
2018	Ferkane	5935	20	0	0	0–0.031
2018	Tehini-Sud	2518	8	0	0	0–0.079
2018	Djonbal	8284	28	1	0.012	0.0003–0.062
Subtotal		35,398	118	3	0.009	0.001–0.024
2019	Manoa	1094	4	0	0	0–0.159
2019	Baho Ouessa	412	1	0	0	0–0.319
2019	Boukero	2681	9	0	0	0–0.071
2019	Maregnawa	3852	13	0	0	0–0.049
2019	Ferkane	1242	4	0	0	0–0.159
2019	Tehini-Sud	129	0	0	0	0–1.477
2019	Tampour/Tobo	82	0	0	0	0–2.314
2019	Kpeni/Mabba	791	3	0	0	0–0.213
2019	Djonbal	3897	13	0	0	0–0.049
Subtotal		14,180	47	0	0	0–0.013

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

Table 7

Onchocerciasis transmission along the Bambassou River during 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2018	Bambassou	9133	30	1	0.013	0.0003–0.058
2019	Bambassou	1591	5	1	0.074	0.002–0.385

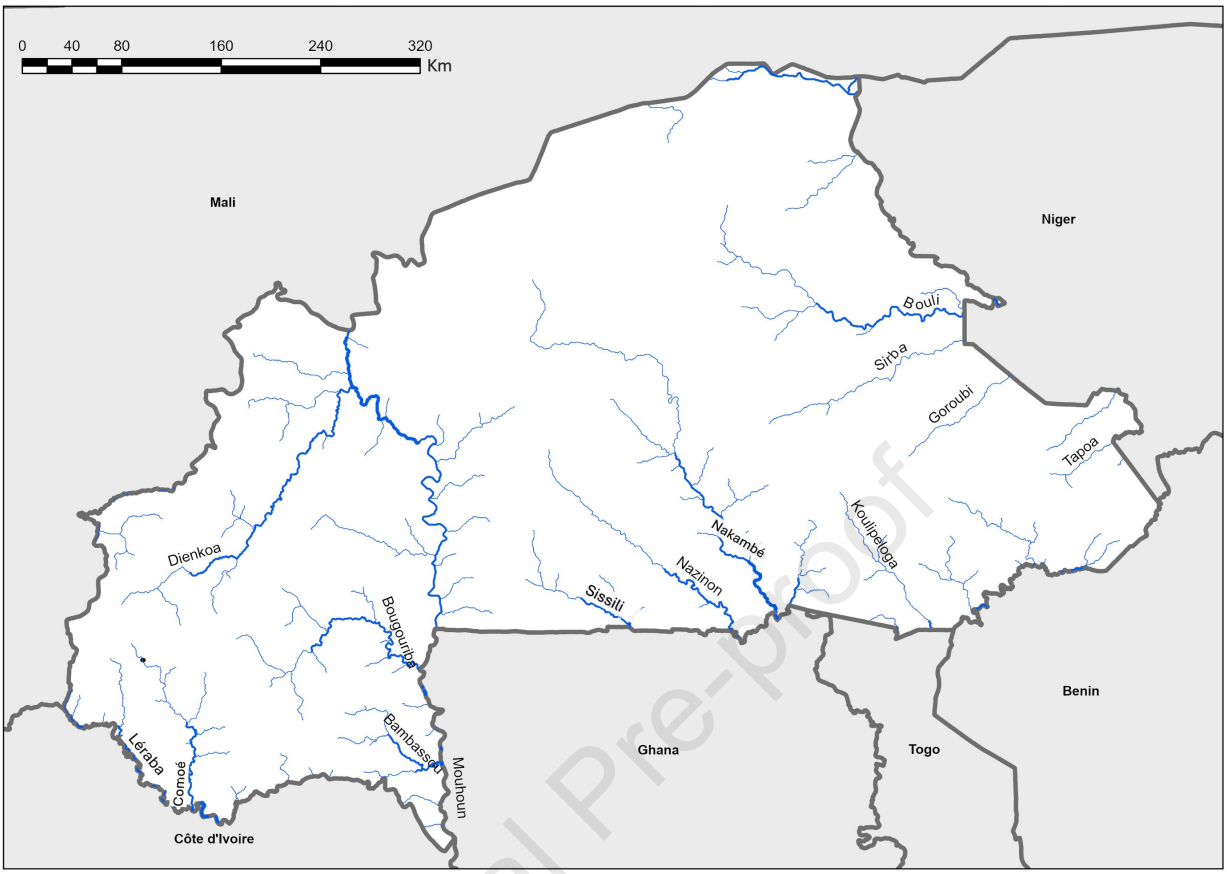
Abbreviation: *N*, number of samples analyzed; CI, confidence interval.

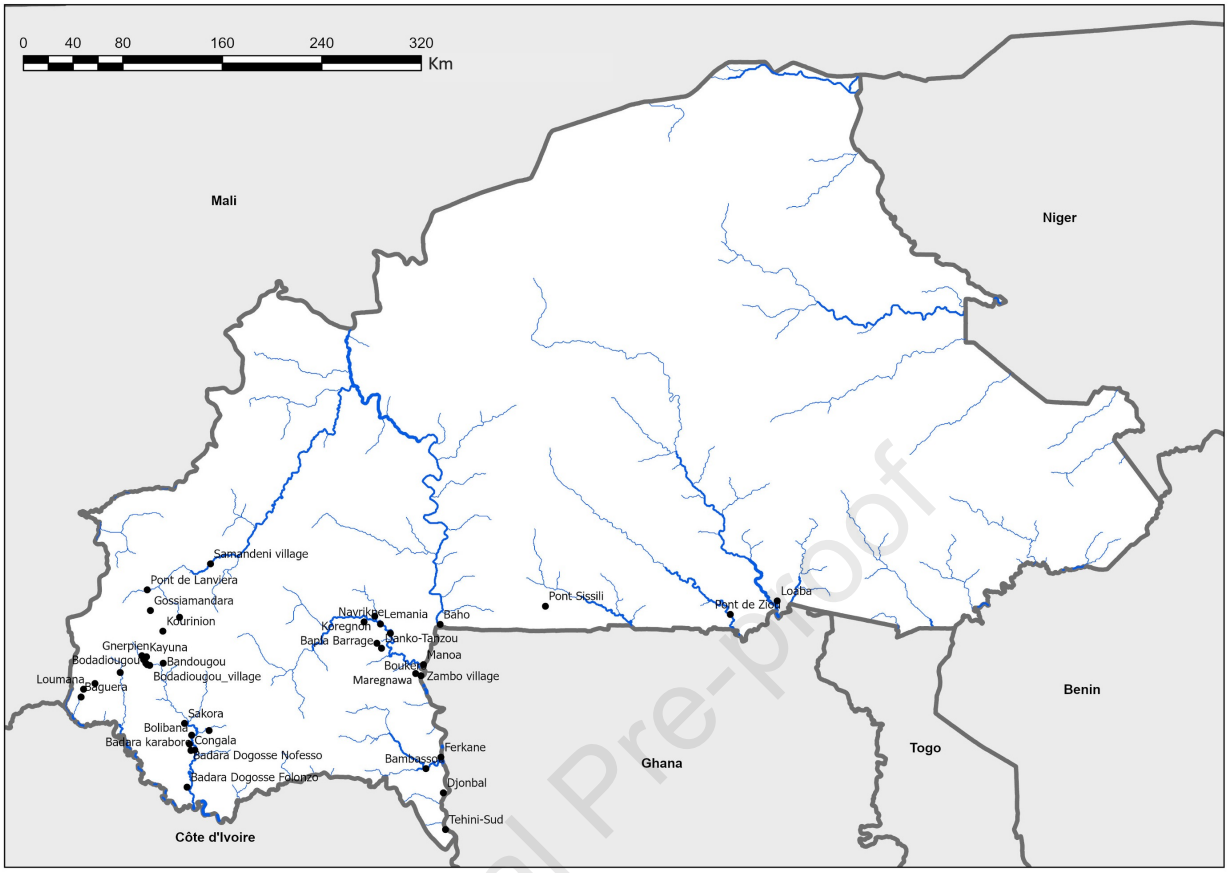
Table 8

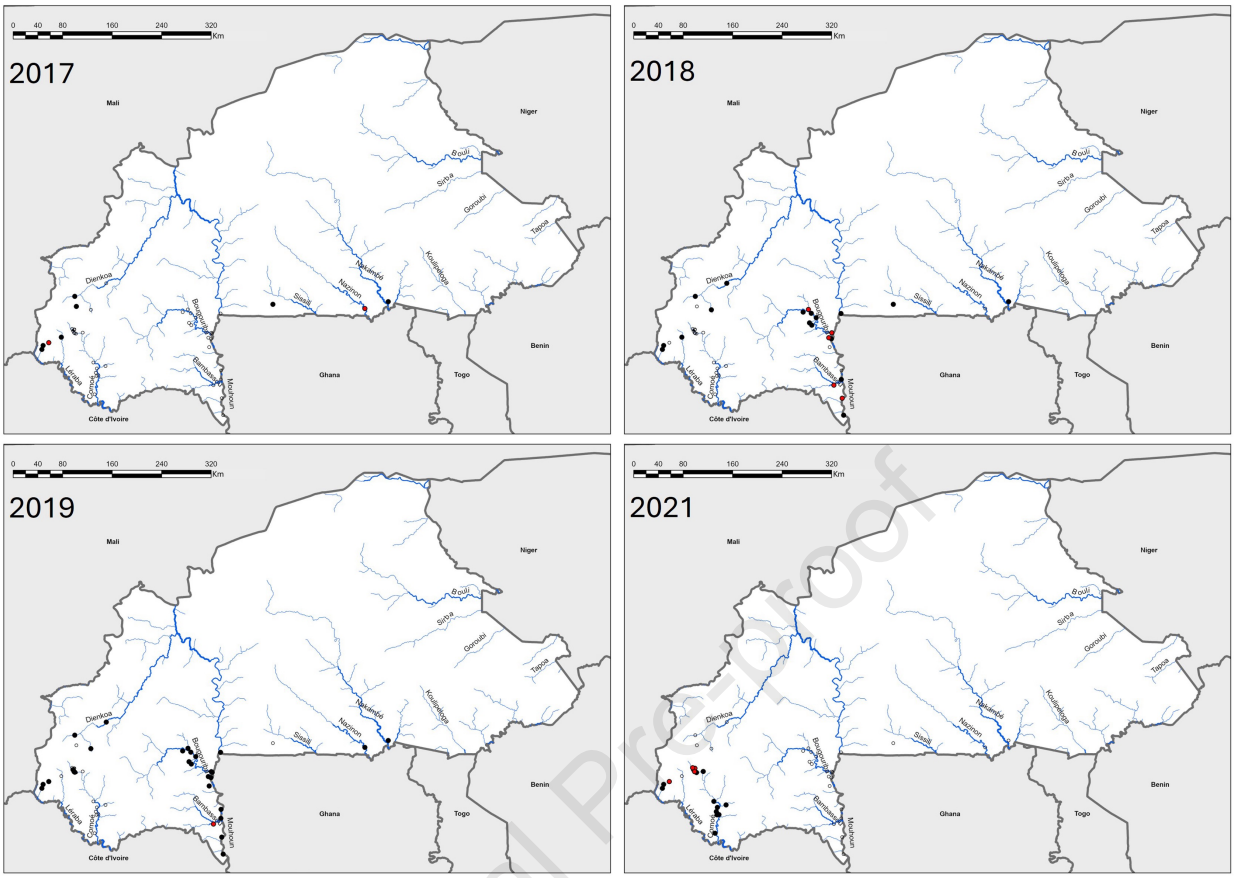
Onchocerciasis transmission along the Nakambé, Nazinon and Sissili rivers during 2017, 2018 and 2019.

Year	Capture point	*N*	No. of pools analyzed	No. of positive pools	Infectivity rate (%)	95% CI (%)
2017	Loaba	1009	4	0	0	0–0.210
2018	Loaba	870	3	0	0	0–0.213
2019	Loaba	88	1	0	0	0–2.158
2017	Pont Sissili	104	1	0	0	0–1.829
2018	Pont Sissili	1 573	5	0	0	0–0.127
2017	Ziou	2007	7	1	0.052	0.001–0.270
2019	Ziou	42	1	0	0	0–4.468

Abbreviation: *N*, number of samples analyzed; CI, confidence interval.







Highlights

- Important variations of *Simulium damnosum* (*s.l.*) density detected along 9 river basins in Burkina Faso during 2017–2021.
- *S. sirbanum* was the major vector; *S. damnosum* (*s.s.*) and hybrids of *S. damnosum* (*s.s.*) × *S. sirbanum* were identified.
- Infectivity rates were below the WHO threshold of 0.05% for all the nine river basins investigated.
- Results indicate an important step toward interrupting onchocerciasis transmission in Burkina Faso.
- Persistence of onchocerciasis transmission hotspot points in boundary regions is indicated.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: