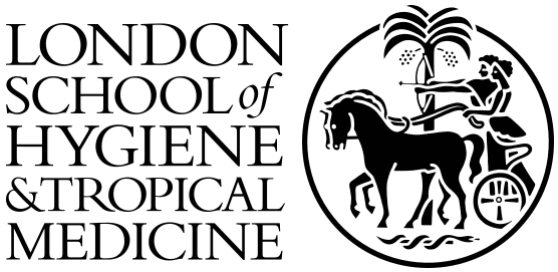

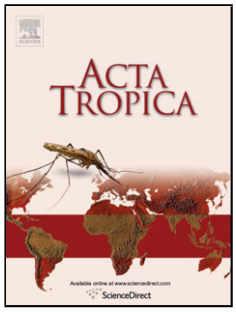

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ACTA TROPICA ORIGINAL RESEARCH ARTICLE

Onchocerciasis prevalence, human migration and risks for onchocerciasis elimination in the Upper Mouhoun, Nakambé and Nazinon river basins in Burkina Faso

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Abstract:

Historically, the whole of Burkina Faso was considered to be endemic for onchocerciasis (except a small area in the far north of the country) with prevalence rates 60-80%, but all endemic areas were included in the World Health Organisation Onchocerciasis Control Programme, which operated a system of vector control by larviciding beginning in 1974. In Burkina Faso larviciding had been phased out by 1989 when it was considered that onchocerciasis had been reduced to levels below the transmission breakpoint (and any residual infections would disappear without further intervention). There was never any mass drug administration against onchocerciasis in Burkina Faso, except in the Bougouriba and Comoé river basins (from 1996 and 2011 to present respectively) because in each of these two areas there was a resurgence of infection, and in parts of the Nakambé River basin and Sissili River basin from 1992 to 1998. However, mass drug administration with ivermectin was also phased in across the whole country starting in 2000 using ivermectin against lymphatic filariasis and is currently being phased out (depending upon the epidemiological parameters). In this publication we report a new epidemiological survey for onchocerciasis which was carried out in 2014 in the Upper Mouhoun, Nakambé and Nazinon river basins in Burkina Faso to evaluate the prevalence and intensity of infection of onchocerciasis. A total of 11,195 people from 61 villages were examined across these three river basins, and onchocerciasis prevalence by skin-snip was below 5% in all villages**,** below 1% in 57 villages (93% of 61 villages) and zero in 47. In the 14 villages with positive skin snips, prevalence figures ranged from 0.31% to 3.50 %. During the survey 31 infected individuals were found. All of them were Burkinabé, of whom 30 had a recent history of residence in Côte d'Ivoire (with a range of 0.5 to 73 microfilariae per skin-snip from two snips per person) and only one had no history of migration and presumably had an autochthonous infection (mean of 0.5

microfilariae per skin snip from two snips). According to parasitological indicators listed by the World Health Organization African Programme for Onchocerciasis Control in 2010, the situation for onchocerciasis was considered to be satisfactory in all three river basins and probably below the transmission threshold, in which case the disease should disappear naturally without the need for further intervention in the absence of continuing immigration. However, the results clearly indicate that infected persons coming from endemic zones of Côte d'Ivoire are settling in small communities which are otherwise nearly free from onchocerciasis in Burkina Faso. They are thus a source of continuing re-introduction of the parasite into the basins and could be a risk for the achievement of onchocerciasis elimination in all three basins. This would justify the continuation of periodic epidemiological surveys to monitor the possible recrudescence of the disease, and entomological (vector) surveys should be undertaken to assess and monitor the residual transmission.

KEY WORDS*: Burkina Faso. Onchocerciasis, Elimination, Human migration, Cross-border, Onchocerciasis Control Programme.*

1. INTRODUCTION

West Africa had some of the largest and most severe endemic onchocerciasis foci in the World before the onset of the West African Onchocerciasis Control Programme (WHO-OCP) in 1974. Within the OCP area there were between 2 and 2.5 million people infected with onchocerciasis in 1973 and an estimated 120,000 blind people. Burkina Faso was part of the OCP from the outset, and it had about one million infected people, of whom 35,000 to 40,000 were blind (WHO, 1985). All river basins had high prevalence (from 60% to over 80% skin-snip positive over large areas), incidences above 10%, community microfilarial loads (CMFL) above (sometimes well above) 10, rates of blindness reaching 10% in the most afflicted

villages, vector biting rates exceeding 20,0000 bites per person per month in most basins, and annual transmission potentials very frequently higher than 1,000 L3 larvae of *Onchocerca volvulus* in the most affected first-line villages. Large areas of fertile river valleys (one third of the arable land of the country) were uninhabitable because of onchocerciasis (WHO, 1985).

OCP was operational from 1974 to 2002 under the executive leadership of World Health Organization (WHO), with the guidance of a committee of four sponsoring agencies and a committee of experts, and financing from a consortium of international donors.
The initial OCP control strategy (1974-1988) was exclusively limited to the application of larvicide against the vector *Simulium damnosum s.l.* After 1988 larviciding was combined in most river basins with chemotherapy by mass distribution of ivermectin (Mectizan R) (Guillet et al., 1995). Ivermectin is a microfilaricidal drug that is safe for use in mass campaigns and given free of charge by its manufacturer (Merck - MSD). Ivermectin was initially distributed by mobile teams, and after 1995-99 by community-based methods, especially Community Directed Treatment with Ivermectin (CDTI) (WHO, 1994). Apart from OCP, no vector control activities have been conducted in the area concerned.

At the end of OCP in 2002 there was a small number of areas where treatments were prolonged for a further five years (the so-called "Special Intervention Zones" in the Upper Niger and Upper Tinkisso basins in Guinea, Upper Oti and Upper Ouémé in Togo and Benin, and in Sierra Leone), but in all other areas onchocerciasis was considered to be below the epidemiological threshold for self-sustaining transmission (and had already disappeared, or would disappear of its own accord without further intervention – see APOC, 2010), and was therefore no longer a public health problem or an obstacle to socio-economic development for the member states. Thus, in Burkina Faso, like most other OCP countries, the onchocerciasis

situation was considered satisfactory and anti-vector treatments had already been phased out basin-by-basin in Burkina Faso. The epidemiological and entomological indicators of infection and transmission had been reduced below acceptance thresholds (prevalence below 5% by skin snip and vector infectivity rate less than one infective female per 1,000 parous biting female vectors) (Agoua et al., 1995).

After 2002, OCP's former participating countries had to ensure (by their own means) periodic entomological and epidemiological surveillance so as to detect in a timely manner any possible onchocerciasis infection and recrudescence of transmission, and to bring the situation back under control where this might be necessary. In this context, Burkina Faso's National Onchocerciasis Control Programme (NOCP -set up in 1991) was responsible for maintaining the success achieved by OCP in the country. The surveillance methods implemented by the NOCP consisted of periodic epidemiological surveys of sentinel villages using skin-snips to detect microfilariae (Prost & Prod'hon, 1978; WHO, 1994) and entomological surveillance of biting blackflies using human landing catches at fixed catching points to detect and count infective L3 larvae by dissection (Toé et al., 1997; WHO, 1987; Yameogo et al., 1999). NOCP was also to instigate CDTI if necessary (WHO, 1994), including monitoring of geographic and therapeutic coverage, and IEC (Information, Education and Communication) surveys.

Results of the epidemiological assessment carried out in 2010 in the Comoé river basin in South West Burkina Faso (in Cascades Health Region – see Figure 1) showed skin-snip prevalences of onchocerciasis above the acceptance threshold of 5% and even up to 70% in some villages (Koala et al., 2017; PNLO, 2010). This was an unexpected and worrying result because in this basin, as in others, onchocerciasis had been reduced below the level at which it

was self-sustaining when OCP was closed and the area had been under annual MDA with ivermectin against lymphatic Filariasis since 2004. The earlier results of epidemiological assessments of nine communities in the Comoé river basin conducted in 2003 (also using skin-snips) had already given indications of problems, with 89 people found positive for microfilariae out of 3,515 examined, i.e. an average prevalence of 2.53% (range 0.8% - 6.3%). The maximum level of infection was recorded at Diandoura, with a prevalence of 6.3% and a CMFL of 0.21 microfilariae per biopsy. During the same period, a skin-snip survey conducted in five villages on the Léraba river examined 1,118 people, of whom only six were positive, with an average prevalence of 0.54% (range 0.9% -<1.5%) and CMFL ranging from 0.02 to 0.1. The Léraba River is also in Cascades Health Region and is a large tributary of the River Comoé.

In 2010, a migration survey in the Upper Comoé basin had shown that of 427 infected persons surveyed, 421 had never traveled or lived outside their locality for long periods of time. The increase in the infection therefore reflected a recrudescence of local (autocthonous) onchocerciasis transmission, but it was unclear whether this was the result of the survival of sufficient numbers of parasites in the local population after 1989 (when vector control had been discontinued) to re-activate transmission, or whether transmission was re-activated by immigration of parasites carried by immigrant vectors. In any case it was unlikely to be immigration of parasites carried by people, because few infected people had a history of travel (Koala et al., 2017). Biannual CDTI for onchocerciasis elimination was subsequently instigated in 2011 for the first time in the Comoé basin following the elimination strategy published by the African Onchocerciasis Control Program (APOC, 2010; Koala et al., 2017) and continues to date. This was the second campaign of ivermectin mass chemotherapy directed against onchocerciasis in Burkina Faso, after one in the Bougouriba river basin instituted in 1996, following a recrudescence in entomological parameters (Borsboom et al,

2003; PNLO, 2010). Treatment with ivermectin was annual and was carried out by mobile teams from 1996 to 1999, when it became community-based and increased to twice a year (biannual) in 2001, and community-directed from 2013 until now.

It is in view of the recrudescence of onchocerciasis in 2010 in the upper Comoé basin the Burkinabé NOCP undertook a series of epidemiological surveys of onchocerciasis in the upper Mouhoun, Nakambé and Nazinon river basins, to investigate whether recrudescence in Burkina Faso might be more widespread. We present in this article the results of these surveys carried out from March to June 2014.

2. PRESENTATION OF THE STUDY AREA

2.1 Geography of the Study Area

The epidemiological assessments were carried out in the river basins of the upper Mouhoun (ex. Volta Noire), Nazinon (ex. Volta Rouge) and Nakambé (ex. Volta Blanche), which constitute the major basins of the Volta River hydrographic system. They are adjacent to each other with the Upper Mouhoun including most of the western part of Burkina Faso (in Sud-Ouest, Boucle de Mouhoun and Hauts-Bassins Health Regions), and directly to the east lies the Nazinon and the Nakambé basins which together occupy most of the central part of the country (within the Centre-Sud and Centre-Est Health Regions). The River Sissili is also part of the Volta river basin and lies between the Nazinon river basin and the Mouhoun river basin (forming the western border of the Centre-Sud Health Region in southern Burkina Faso before it crosses the international frontier into Ghana). The study area is shown in Figure 1, including

the location of survey villages, and lies within four administrative health regions (Hauts-Bassins, Boucle du Mouhoun, Centre-Sud and Centre-Est Regions).

The study area is fairly flat and mostly lies at altitudes between 200 and 400 m except for some higher lands in the west (most notably the Massif Gesseux in Hauts-Bassins Region) which rarely get above 600 m. There is a single rainy season May to October with a south-north decline in annual rainfall from about 1000 to 800 mm. The vegetation is savanna, with guinea savanna in the south and sudan savanna in the north, reflecting the pattern of rainfall (Jeune Afrique, 2005). Vector blackflies known from the study area are almost exclusively *Simulium sirbanum*, with a few *S. damnosum* s.str. in the lower parts of the R. Mouhoun (Boakye et al., 1998).

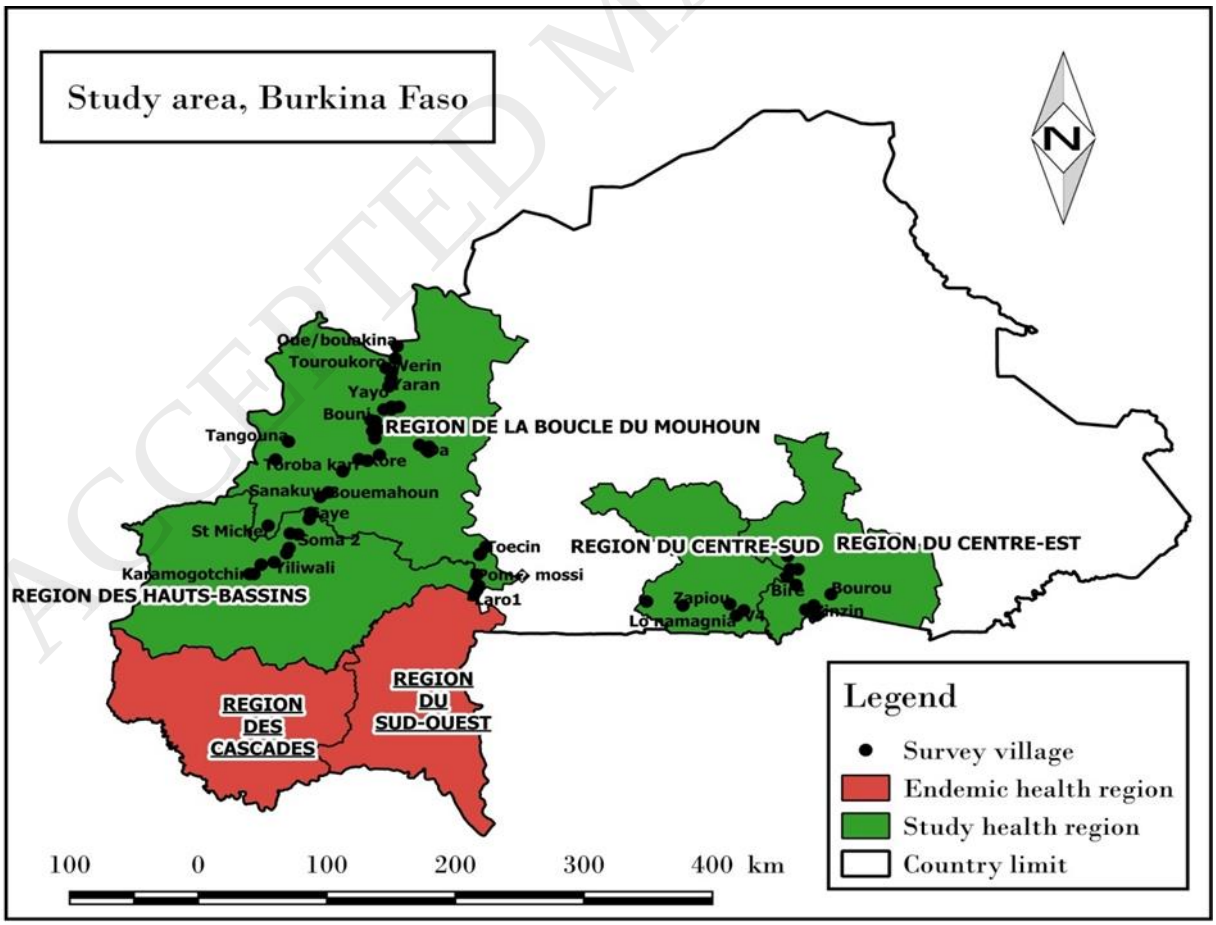

Fig. 1. Study area in Burkina Faso and the villages surveyed. The Health Regions included in the study are shown in green, and Health Regions with a problematic history of onchoceciasis elimination are shown in red. There were recrudescences of onchocerciasis in the Bougouriba valley in the Region du Sud-Ouest in 1994 (Borsboom et al., 2003) and in the Comoé River valley in the Region des Cascades in 2010 (Koala et al., 2017) (see section 1 above).

2.2 History of Onchocerciasis Control in the Study Area

There were 14 to 15 years of vector control in the study area carried out by OCP from 1974/5 to 1989. No mass treatments with ivermectin were carried out before 2000 (when the LF programme was started – see below) in the "Boucle du Mouhoun" and the Nazinon basin, but all people found positive during the epidemiological evaluations were treated (see Nikiema et al., 2018 - Dataset 1). By contrast, mass treatment with ivermectin against onchocerciasis was carried out in parts of the Nakambé River basin and Sissili River basin from 1992 to 1998. This distribution was made in the health districts of Léo and Po and involved several villages including Kounou, Kassian, Tian, Boala, Oualem, Natiedougou (see Nikiema et al., 2018 - Dataset 2).

In 2000, the whole of Burkina Faso was classified as a being endemic for Lymphatic Filariasis (LF), with prevalence rates ranging from 2% to 74%. A national elimination programme for LF elimination was therefore established in 2000, and this programme established Mass Drug Administration (MDA) with ivermectin throughout the country. In the Boucle du Mouhoun, distribution was carried out from 2005 to 2016. In the Nazinon and Nakambé basins, treatments started in 2002 and are expected to stop in 2017. All the river basins therefore received mass treatments with ivermectin over 12-15 years for the elimination of LF, and whilst this was not specifically directed against onchocerciasis it should have acted to suppress any residual autochthonous transmission and hence complete

the work of OCP where onchocerciasis infections might have persisted or been re-introduced by immigration of vectors and/or humans.

It is important to note that after 2002 epidemiological assessments (by skin-snips) were infrequent due to lack of funding and were carried out only the upper Mouhoun (6 villages in 2003 and 2 villages in 2005), Bougouriba, Oti-Pendjari, Kompienga, Comoé, Léraba and Dienkoa basins between 2003 and 2009 (see Nikiema et al., 2018 - Dataset 3). In addition, the villages in the basins were different at each assessment. In the case of entomological assessments, monitoring was also irregular in the three basins after the end of OCP. Thus, in 2006, transmission on the Nazinon (at Ziou) and Nakambé (at Loaba) was assessed and the infectivity rates were 0.069‰ and 0.39 ‰ respectively (measured from human landing catches with dissection of flies for infective L3 larvae). The Nazinon (at Ziou) was reassessed in 2009, and vector infectivity rate in all flies was 0.24 ‰.

3. MATERIAL AND METHODS

3.1 Selection of Communities in the Different Basins

A total of 61 communities were selected from across the three river basins with the assistance of the Health District officials. There were 47 in the Upper Mouhoun basin, eight in the Nakambé basin and six in the Nazinon basin. Communities selected for the survey were those that met the following criteria established by OCP: 1) be located between 0 and 10 km from the river; 2) a high level of onchocerciasis infection in the past; 3) be located near an important vector breeding site; 4) be located "on the front line", i.e. there must be no other permanent community between the village and the nearest vector breeding site; 5) not be

overpopulated; their population had to be about 200 to 300 inhabitants; 6) have a stable population; the migratory movements of village dwellers must be limited in time and space.

3.2 Evaluation of Onchocerciasis Infections

Epidemiological surveys were carried out in March-June 2014, at least 12 months after the previous mass administration of ivermectin by the LF programme (which had temporarily suspended its treatment programme to carry out its own assessments). During the epidemiological surveys, the survey team first sensitized the local administrative and health authorities on the importance of the proposed epidemiological assessments. At the next step, on the day before the evaluation survey, the team visited the selected villages and carried out a population awareness campaign on the disease, the control measures, and the importance of the epidemiological assessment and surveillance.

The survey was a cross-sectional descriptive survey using WHO-OCP epidemiological surveillance/evaluation methodology (WHO, 1994). Firstly on the day of the survey, a census was carried out of the entire population of the village by family. The persons examined were all those who were present and registered in a household, and who accepted to be examined. A bloodless cutaneous biopsy (skin-snip) was taken from both the left and right iliac crests of all participating inhabitants of villages aged five years and older using a Holth 2 mm punch, like those used in previous surveys, to collect a calibrated snip. The biopsies were incubated in distilled water for 30 minutes, after which the number of microfilariae which had emerged was counted using a binocular microscope. The negative snips were transferred to physiological saline and incubated for a further 24 hours and the numbers of emergent microfilariae was re-assessed as recommended by Prost & Prod'hon, (1978). This was standard method applied by WHO-OCP (Remme, 2004), and hence our data are consistent

with previous studies in Burkina Faso and other historical data. Microfilariae from positive snips were fixed on microscope slides and shipped to the Molecular Biology Laboratory of the WHO Multi- Disease Surveillance Center (MDSC) in Ouagadougou for molecular identification using O-150 PCR, which confirmed that all of them were *O. volvulus*.

3.3 Human Migration Survey

The purpose of this survey was to assist the interpretation of the epidemiological survey by assessing the possibilities that infections may have been picked up during residence in the survey village or elsewhere. Immigrants may be from other parts of Burkina Faso, or they may be from other countries permanently settling in Burkinabé valleys. Other migrants can include people originally from the three basins who are returning after a more or less prolonged stay elsewhere.

A migration questionnaire survey was conducted on all individuals with a positive skin biopsy. The questionnaire recorded their place of birth, their profession, their places of residence away from the survey village during the last ten years and the existence of watercourses in the vicinity of their place of residence and work, the duration of any stay outside the survey village, and the date they settled in the survey village after the period outside. The survey form was originally developed and applied by OCP for their own migration studies of people with microfilariae.

3.4 Indicators Used

The coverage of the epidemiological survey in each village is expressed as a percentage of the number of persons examined by the skin-snip, in relation to the total number of inhabitants recorded in the initial census carried out on the day of the survey. The indicators used to

determine the level of endemicity of onchocerciasis and the intensity of infection in each community were the gross prevalence and the community microfilarial load (CMFL). CMFL is the geometric mean number of microfilariae detected in the calibrated skin snips (see above) calculated from all the people aged 20 years or more examined in a community, the gross prevalence is the proportion of subjects examined who were found to be positive for microfilariae in skin snips and the standard prevalence is standardized by age and sex using the OCP reference population (see Moreau et al, 1978).

3.5 Ethical Considerations

In 2009, the National Ethics Committee gave blanket approval for carrying out the routine activities of the NOCP for the control and elimination of onchocerciasis (including epidemiological evaluation as carried out for this study). On the day of the survey, the team organised an awareness meeting with the survey village population about the disease and its diagnosis using skin snips. We then collected free and informed, oral consent of persons of 18 years of age or over. For those whose age was less than 18 years, the oral consent of the parents or guardians was collected. The anonymity of the people has been preserved in database records used for analyses (except that all individuals found to have a positive skin snip were offered treatment with ivermectin at the nearest Health Centre). The results on the field survey forms were entered into a database by the Data Manager of the Onchocerciasis Elimination Unit of the Program for the Control of Neglected Tropical Diseases. On the survey forms each household is given a number during fieldwork, and whist entering data entry into the database names are removed and each household individual is assigned a number. Only the program manager and the NOCP data manager had access to the field data collection forms. After the field investigation and transfer of data into the anonymized database, the NOCP makes a formal report that does not include names.

4. RESULTS

4.1 Endemicity of Onchocerciasis

The population census indicated a total of 20,357 residents were living in the 61 communities surveyed (Table 1). Skin snips were taken from 11,195 persons with coverage ranging from 54.6% to 56.1% according to river basin (Table 1).

Of the 61 villages evaluated, 47 (77.04%) had zero prevalence of onchocerciasis according to skin snips, and 14 (22.96%) communities included at least one infected person (Table 2). All communities were found to have prevalences of less than 5%, and 57 (93.44%) had prevalences of less than 1%. Out of 47 communities surveyed in the upper Mouhoun basin 35 (74.4%) showed zero prevalence, and similarly 7 out of 8 in the Nakambé basin and 5 out of 6 in the Nazinon basin. The gross prevalence ranged between zero and 3.50% in the upper Mouhoun, zero to2.99% in the Nakambé basin and zero to 0.64%in the Nazinon basin (Table 2). In all the villages surveyed the CMFL was below 0.5. It should be noted that CMFL is presented as being zero in five villages of upper Mouhoun which showed a positive prevalence. This is because the CMFL was calculated only from persons over the age of 20 years.

Table 1: Census and skin snip results by river basin.

Basin	Number of villages visited	Registered inhabitants of villages visited	People examined by skin snip	
			number	Percentage
Upper Mouhoun	47	15471	8453	54,6%
Nakambé	8	3071	1723	56,1%
Nazinon	6	1815	1019	56,1%
Total	61	20357	11195	55,6%

Table 2: Endemicity of onchocerciasis per basin and in villages showing a positive gross prevalence at the skin snip.

Bassin	Village	Registered population of each village	Population examined	Number infected	Gross prevalence (%)	Standard prevalence	CMFL
Upper Mouhoun	Sirafala	211	140	1	0.71	1	0
	Saye	557	324	1	0.31	0.2	0
	Saint Michel	572	270	1	0.37	0.5	0.01
	Tangouna	346	255	1	0.39	0.6	0.004
	Toungo	398	223	1	0.45	0.2	0
	Tomakoura	257	163	1	0.61	0.4	0
	Kamendena	435	184	1	0.54	0.4	0
	Koré	403	187	1	0.53	0.9	0.02
	Pomé Mossi	298	145	2	1.38	1.1	0.03
	Nawiya	403	227	1	0.44	0.4	0.02
	Sadon	289	190	6	3.16	3.5	0.06
	Laro1	390	200	7	3.50	4.5	0.030
Total		4559	2508	24	0.95		-
Nakambé	Zinzin	390	201	6	2.99	2.6	0.04
Nazinon	Bourou	387	156	1	0.64	0.3	0.03
TOTAL		5336	2865	31	1.08		-

4.2 Migration Survey

Of the 11,195 people examined by skin-snip, 31 were found to be infected. The migration survey was therefore carried out in these people. The results showed that only one of them (a resident of the village of Tangouna village in the Haut Mouhoun basin) had not made a long stay or moved outside his area of residence during the last ten years. The 30 other positive

people were Burkinabé who had returned to Burkina Faso in 2013 or 2014 after a long stay in Côte d'Ivoire, where they had stayed around Soubré and Sassandra. Both of these areas are characterised by extensive vector breeding sites on the lower Sassandra River, they are meso- and hyper-endemic for onchocerciasis and have not been subject to any vector control or MDA against onchocerciasis (Philippon, 2007).

Table 3: Parasitological details of persons found to be mf positive.

Village	**Infected person i.d. number**	**Age (year) in 2014**	**Mfs per skin-snip**			**Date of return into area**
			SSL	SSR	Mean	
Sirafala	1	6	0	2	1	2013
Saye	1	19	6	4	5	2014
Saint Michel	1	40	2	1	1,5	2014
Toungo	1	17	2	0	1	2014
Toumakoura	1	9	1	2	1,5	2014
Kamandena	1	12	0	1	0,5	2013
Koré	1	30	6	2	4	2014
Pomé mossi	1	28	12	0	6	2014
	2	7	3	7	5	2014
Nawiya	1	33	2	2	2	2014
Sadon	1	39	0	2	1	2014
	2	35	16	2	9	2014
	3	7	0	5	2,5	2014
	4	30	3	1	2	2014
	5	5	5	0	2,5	2014
	6	58	3	1	2	2014
Laro1	1	17	61	85	73	2014
	2	30	0	1	0,5	2014
	3	26	10	15	12,5	2014
	4	42	1	0	0,5	2014
	5	13	4	34	19	2014
	6	9	24	5	14,5	2014
	7	5	7	3	5	2014
Zinzin	1	17	3	2	2,5	2013
	2	30	17	28	22,5	2013
	3	54	1	0	0,5	2013
	4	37	1	0	0,5	2013
	5	11	2	3	2,5	2013
	6	9	9	11	10	2013
Tangouna	1	30	0	1	0,5	Autochthonous
Bouro	1	28	48	16	32	2014

5. DISCUSSION

Recent WHO onchocerciasis guidelines for stopping mass drug administration and verifying elimination of human onchocerciasis (WHO, 2016) recommend against the use of skin-snip data for determination of whether levels of infection in a community have dropped below the epidemiological threshold at which transmission can be sustained and ivermectin distribution can be stopped. This is because skin-snip microscopy is not very sensitive to low levels of infection. However, the guidelines do consider that skin-snip data can be used to measure progress towards elimination and earlier guidelines (APOC, 2010) attempted to define (albeit provisionally) transmission thresholds in terms of skin-snip microscopy. APOC (2010) suggested that a prevalence of mf < 5% in all surveyed villages, and < 1% in 90% of surveyed villages (by skin-snip) indicated that levels of infection were probably below the transmission threshold, but this should be confirmed by entomological evaluation of transmission. Given the overall values of the indicators recorded in 2014, the onchocerciasis situation was considered to be satisfactory in the upper Mouhoun, Nakambé and Nazinon basins since these values were below the upper thresholds of acceptability indicated by APOC (2010). CMFL values were in all communities much lower than the acceptability threshold of 0.5 mfs/s (Dadzie et al., 1991; APOC, 2010) and ranged from 0 to 0.06 mf/s. APOC (2010) also recommended that these levels should be maintained for several years after intervention is discontinued to ensure that infections did not recrudescence. There was a recrudescence event in the Comoé valley in Burkina Faso after cessation of vector control (Koala et al., 2017), but the levels of infection recorded in the three river basins in this study have remained very low (probably below the transmission threshold) and the only real question is whether this is a

continuing low-level of autochthonous transmission or whether it is the result of immigration of parasites mediated by human migration from elsewhere.

In theory, the recrudescence of infection in an area may be caused either by local increase in transmission of residual infections or by reintroduction of the parasite associated with migrations of infected persons or the immigration of vectors carrying the parasite. In our study area it is theoretically possible that in a few communities local levels of infection may never have been brought below the transmission breakpoint, and hence transmission continued and may have spread. It is also possible that the threshold for transmission may be lower in some communities due to local conditions (efficiency of the local vector cytospecies and local biting rates for example). In communities which had been subject to effective interventions it is possible that subsequent immigration of parasites (in humans) might increase the levels of infection above the transmission breakpoint and result in recrudescence. It is also theoretically possible that levels of infection were brought below the transmission breakpoint everywhere, but random statistical variation in transmission (so-called stochastic effects) pushed infection levels above the breakpoint and re-established a self-sustaining focus of infection.

The migration survey of infected people yielded information relevant to the geographical origin (local or imported) and the age (new or old) of the infection to help distinguish these possibilities. An infection may be considered new and local when a person found to be infected was not infected at the time of the last visit and had not traveled or had not been away from their area of residence for the last ten years. Only one infected person (out of 31 recorded in this survey) was found to have no history of migration. This person was an inhabitant of the Upper Mouhoun basin, and was an old infection, because the person had

been recorded as infected in an earlier survey in 2008, when the overall prevalence recorded in the village had been 3.94% (PNLO, 2011). The remaining 30 infected individuals were all Burkinabé but they had a migration history, having resided in Côte d'Ivoire and returning to Burkina Faso in 2013 or 2014 to settle in small rural communities along rivers in the three basins. In these areas, the vector is present and the preventive chemotherapy with ivermectin (against LF) has been interrupted or is about to be interrupted. It therefore seems that nearly all of the infections have been acquired elsewhere and have been imported with migrants. However, this is clearly a risk for onchocerciasis elimination in these basins.

In the present study, the basins tested had not been subjected to ivermectin treatments in a campaign specifically directed against onchocerciasis. However, the three basins were under Mectizan treatment by the National Program for Elimination of Lymphatic Filariasis, which ended in 2016 in the Mouhoun basin and will end in 2017 in the Nazinon and Nakambé basins. The results of this study do not support a resumption or extension of these treatments, from the sole point of view of onchocerciasis elimination, although such decisions may, however, be taken by the LF program according to its own results with regard to the elimination of LF. Stopping of ivermectin therapy, however, requires that periodic monitoring of the onchocerciasis endemicity be maintained in the three basins and that an entomological surveillance system be established to monitor and verify the cessation of transmission by the simuliid vectors.

Our results indisputably demonstrate that in spite 14 to 15 years of vector control (1974/5 to 1989) in our study area infection has not disappeared 25 years after vector control was discontinued. WHO (2016) recommends the use of OV16 ELISA tests on children 5-9 years old (inclusive) for assessing whether the levels of transmission are below the epidemiological

threshold for self-sustaining transmission (because this test is more sensitive than skin snips – and this should be confirmed by vector surveys), but the levels of infection we have found are below the threshold as previously indicated by APOC (2010). It is 25 years since vector control was stopped and there has been no general recrudescence of onchocerciasis prevalence and it is probable that infection is indeed below the transmission threshold (although any such recrudescence may have been held in check by mass distribution of ivermectin against LF). In any case it is clear that the situation represents a threat to onchocerciasis elimination in Burkina Faso, and this is mostly due to immigration of humans carrying parasites.

6. CONCLUSIONS

Epidemiological assessments carried out in 2014 on the upper Mouhoun, Nakambé and Nazinon basins in Burkina Faso show that the level of endemicity of onchocerciasis is satisfactory in these basins according to WHO-APOC guidelines (APOC, 2010). Prevalences are less than 5% in all villages and less than 1% in 93.44% of villages, and CMFLs are well below 0.5. Furthermore, there is no evidence for a general recrudescence of infection since vector control was discontinued in 1989, and so elimination of infection in humans appears to be slow, but on the right track. Therefore, it is not necessary to introduce community-directed treatment for ivermectin for the elimination of onchocerciasis on these basins (as would have been necessary if there had been a resurgence of prevalences and CMFL above the critical thresholds). The 31 individuals found to have a positive skin snip have been offered treatment with ivermectin at the nearest Health Centre and this offer should continue for at least ten years.

Nearly all the people found to be infected (30 out of 31) were Burkinabé with a recent history of residence in endemic areas of Côte d'Ivoire and had later returned to Burkina Faso and settled in communities where onchocerciasis was on the verge of elimination. Within the basins of the upper Mouhoun, the Nakambé and the Nazinon, this sort of cross-border migration represents a source of re-introduction of the parasite which could be a risk to onchocerciasis elimination. However, in practice human migration does not seem to have resulted in widespread resurgence of local transmission, and it seems probable that once the endemic areas of Côte d'Ivoire are eliminated residual infections in Burkina Faso will also disappear. However, until then it is recommended that epidemiological surveillance be continued (including appropriate monitoring of the occupation of sensitive valleys), and a network of entomological surveillance should also be established to carry out periodic vector catches and biomolecular processing of biting flies from reference sites. This surveillance should be parasitological to assess the problem of continuing immigration, and serological (OV-16) on children to assess the possibility of autochthonous transmission. It should be carried out in consultation with the Côte d'Ivoire's NOCP, where outbreaks of onchocerciasis have been recorded (Philippon, 2007), but where the endemic control project has now been rehabilitated. Active consultation with the Ghanaian authorities in charge of the Volta and Sissili river basins is also desirable.

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