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Identification to cytospecies of the vector of onchocerciasis in the Republic of Niger

Robert A Cheke [a,*], Salissou Adamou Batchiri [b], Rory J Post [c], Daniel A Boakye [d,e]

[a] Natural Resources Institute, University of Greenwich at Medway, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK
[b] Programme National de l'Elimination de la Filariose Lymphatique et l'Onchocercose, Ministère de la Santé Publique de la Population et des Affaires Sociales, Niamey, Niger
[c] Medical Entomology Consultancy, Lewes, UK
[d] Noguchi Memorial Institute for Medical Research, University of Ghana, PO Box LG581, Legon, Accra, Ghana
[e] The END fund, 2 Park Avenue, 28th Floor, New York, NY10016, USA

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ABSTRACT

In order to incriminate the vector that was responsible for onchocerciasis transmission in the Republic of Niger, where WHO have declared that the disease has been eliminated, cytotaxonomic identifications were collated from published and unpublished sources. Data on 1205 cytotaxonomic identifications of members of the *Simulium damnosum* complex collected as larvae in the country from 1967 to 1991 showed that, with the exception of five *S. damnosum* s.str., all identifications were *S. sirbanum*, which is thus confirmed as the almost exclusive vector in Niger. Some of the main breeding sites are described and illustrated and circumstantial evidence is presented that the form of *S. sirbanum* commonly found in Niger is zoophilic as well as anthropophilic.

1. Introduction

Onchocerciasis was first recorded in Niger in 1952, but the high prevalence of the disease there did not become evident until skin-snip surveys during 1966-1968 revealed prevalences up to 80% and the geographical distribution of the vectors was also studied (Prost et al., 1977). Niger was thus included within the WHO Onchocerciasis Control Programme (OCP), but it was only with the beginning of the control operations of the OCP in 1976 that standardized surveys were conducted across the programme area to determine both the baseline prevalence of onchocerciasis in Niger (Prost et al., 1977) and the broader distribution of the vectors (Davies et al., 1978). These surveys indicated that transmission was almost entirely limited to tributaries originating in Burkina Faso and flowing across Niger to join the Niger river from the river's right bank. Breeding sites in the Niger river itself were only discovered occasionally (e.g. Balay (1968) found *Simulium damnosum* s.l. breeding in the Niger near Gotheye). All entomological surveys in watercourses bordering the left bank of the Niger were negative, and so they were excluded from the OCP, although a small number of breeding sites were later discovered in Gaya district (Niger Ministry of Public Health unpublished data, per S. A. Batchiri). The distribution of onchocerciasis in Niger was also subject to Onchocerciasis Elimination Mapping in 2019, which confirmed the absence of vectors and transmission outside of the areas already identified (Adamou et al., 2023).

Regular aerial larviciding of all rivers in Niger that were known to harbour breeding sites for *S. damnosum* s.l. was initiated by the OCP in 1977 (Davies et al., 1978), using the organophosphate insecticide temephos (trade name Abate) and continued until 1987-1989 (depending upon locality), when infection rates had dropped to less than 0.5% (which was the OCP target, WHO 1987). By 1995 it was estimated that there were only 32 people infected with onchocerciasis amongst the 7.7 million inhabitants of Niger, although 300 were blind as a result of the disease (WHO 1995). Subsequently, there was some ground-based larviciding in a few places, and annual distribution of ivermectin, along with albendazole given against lymphatic filariasis (LF), throughout all LF-endemic districts. The treated population included all those living in areas that had been known to be endemic for onchocerciasis from 2008 to 2013 or 2010 to 2019 (depending upon district). Recent epidemiological and entomological surveys for onchocerciasis suggested that the disease has been eliminated throughout Niger and, in 2023, Niger became the first country in the African Region to submit a dossier to WHO to verify the elimination of transmission

* Corresponding author.
E-mail address: r.a.cheke@greenwich.ac.uk (R.A. Cheke).

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Table 1
Cytotaxonomic identifications of larvae of the *Simulium damnosum* complex collected in Niger 1976–1991. Initials of collectors and identifiers are as follows: RAC = Robert A. Cheke; GKF = George K. Fiasorgbor; RLB = R. Le Berre; SEOM = Stefanie Meredith; AR = Alfons Renz; SAS = Sammy A. Sowah; OCP= WHO Onchocerciasis Control Programme; CGV=Charles Vajime.

Date	River	Site	Coordinates	DAMNOSUM s. str.	SIRBANUM	Cytotaxonomy notes	COLLECTOR	IDENTIFIER	REFERENCE(S)
(Day.Month. Year)									
19.ix.1984	Niger	N1 (Sagafondo, 25km NW of Niamey)	13 35N 01 57E		7	All 4 males with IS 3/3 karyotype	RAC / SAS / OCP	GKF	Cheke (1984) Fiasorgbor & Cheke (1992)
21.ix.1984	Niger	N6 (7km upstream of confluence with Sirba, near Zara Koyra & Saya)	13 48N 01 36E		11		RAC / SAS /OCP	GKF	Cheke (1984)
04.x.1977	Niger (? Gouroubi)	Djongore	?		4		OCP	CGV	Vajime (1978)
05.x.1967	Sirba	Kwarezenou	? 13 40N 01 32E		16	11 sirbanum + 5 sudanense	RLB	V&D	Vajime & Dunbar (1975)
19.ix.1984	Sirba	N4 (7km downstream of Kakou)	13 15N 01 06E		10	All 3 males with IS-3/3 karyotype	RAC / SAS / OCP	GKF	Cheke (1984); Fiasorgbor & Cheke (1992)
29.ix.1978	Sirba	Kakou	13 15N 01 06E		37		OCP	CGV	Vajime (1979)
20.ix.1984	Sirba	N5	13 10N 01 05E		30		RAC / SAS / OCP	GKF	Cheke (1984)
19.ix.1984	Sirba	N3, Tourey	13 37N 01 27E		1		RAC / SAS / OCP	GKF	Cheke (1984)
??.ix.1977	Sirba	Site 1	?		15		?	CGV	Vajime & Quillévéré (1978)
20.ix.1984	Sirba	N2 Garbey-Kourou	13 44N 01 36E		11	All 5 males with IS-3/3 karyotype	RAC / SAS / OCP	GKF	Cheke (1984); Fiasorgbor & Cheke (1992)
19.ix.1984	Sirba	N2 Garbey-Kourou	13 44N 01 36E		2		RAC / SAS / OCP	GKF	Cheke (1984)
15.viii.1978	Sirba	Garbey-Kourou	13 44N 01 36E		11		OCP	CGV	Vajime (1979)
20.viii.1981	Sirba	Garbey-Kourou	13 44N 01 36E		11		OCP	GKF	Fiasorgbor (1981)
27.viii.1981	Sirba	Garbey-Kourou	13 44N 01 36E		6		OCP	GKF	Fiasorgbor (1981)
23.vii.1982	Sirba	Garbey-Kourou	13 44N 01 36E		41		OCP	GKF	Fiasorgbor (1982)
16.ix.1982	Sirba	Garbey-Kourou	13 44N 01 36E		24		OCP	GKF	Fiasorgbor (1982)
28.vii.1983	Sirba	Garbey-Kourou	13 44N 01 36E		15		OCP	GKF	Fiasorgbor (1983, 1984a)
19.x.1983	Sirba	Garbey-Kourou	13 44N 01 36E		25		OCP	GKF	Fiasorgbor (1984a)
08.viii.1984	Sirba	Garbey-Kourou	13 44N 02 22E		13		OCP	GKF	Fiasorgbor (1984b)
31.x.1991	Sirba	Garbey-Kourou	13 44N 02 22E		50		OCP	GKF	Fiasorgbor (1993)
26.xi.1991	Sirba	Garbey-Kourou	13 44N 02 22E		110		OCP	GKF	Fiasorgbor (1993)
14.x.1986	Gouroubi	Djongore	12 57N 02 16E		13	All 6 males with IS-3/3 karyotype	OCP	GKF	Fiasorgbor (1988)
17.ix.1987	Gouroubi	Djongore	12 57N 02 16E		23		OCP	GKF	Fiasorgbor (1988)
14.x.1976	Gouroubi	Djongore	12 57N 02 16E		57		OCP	CGV	Vajime (1977a); Vajime & Quillévéré (1978)
14.viii.1978	Gouroubi	Djongore	12 57N 02 16E		42		OCP	CGV	Vajime (1979)
16.vii.1982	Gouroubi	Djongore	12 57N 02 16E		31		OCP	GKF	Fiasorgbor (1982)
20.vii.1982	Gouroubi	Djongore	12 57N 02 16E		23		OCP	GKF	Fiasorgbor (1982)
02.ix.1982	Gouroubi	Djongore	12 57N 02 16E		21		OCP	GKF	Fiasorgbor (1982)
14.vii.1983	Gouroubi	Djongore	12 57N 02 16E		21		OCP	GKF	Fiasorgbor (1983, 1984a)
20.x.1983	Gouroubi	Djongore	12 57N 02 16E		34		OCP	GKF	Fiasorgbor (1984a)
28.ix.1989	Gouroubi	Djongore	12 57N 02 16E		10		OCP	GKF	Fiasorgbor et al. (1990)
17.ix.1987	Dyamongou	Diney	12 45N 02 21E		17		OCP	GKF	Fiasorgbor (1988)
30.vi.1982	Dyamongou	Diney	12 45N 02 21E		13		OCP	GKF	Fiasorgbor (1982)
28.ix.1989	Dyamongou	Near Diney	12 45N 02 23E	**2**	82		OCP	GKF	Fiasorgbor et al. (1990)
20.vii.1977	Tapoa	Site 3	?	**1**	19		OCP	CGV	Vajime (1977b); Vajime & Quillévéré (1978)
11.ix.1986	Tapoa	Tapoa	12 28N 02 25E		16	All 7 males with IS-3/3 karyotype	OCP	GKF	Fiasorgbor (1988)
21.viii.1987	Tapoa	Tapoa	12 28N 02 25E		21		OCP	GKF	Fiasorgbor (1988)

(*continued on next page*)

Table 1 (*continued*)

Date	River	Site	Coordinates	DAMNOSUM s. str.	SIRBANUM	Cytotaxonomy notes	COLLECTOR	IDENTIFIER	REFERENCE(S)
17.ix.1987	Tapoa	Tapoa	12 28N 02 25E		16		OCP	GKF	Fiasorgbor (1988)
13.vi.1981	Tapoa	Tapoa	12 28N 02 25E		7		OCP	GKF	Fiasorgbor (1981)
16.vi.1982	Tapoa	Tapoa	12 28N 02 25E		35		OCP	GKF	Fiasorgbor (1982)
06.viii.1982	Tapoa	Tapoa	12 28N 02 25E		24		OCP	GKF	Fiasorgbor (1982)
28.ix.1989	Tapoa	Tapoa	12 28N 02 25E	1	89		OCP	GKF	Fiasorgbor et al. (1990)
13.vi.1981	Mékrou	Gorges Mékrou	12 18N 02 37E		28		OCP	GK	Fiasorgbor (1981)
21.v.1982	Mékrou	Gorges Mékrou	12 18N 02 37E		12		AR /OCP	GKF	Renz (1983)
26.v.1982	Mékrou	Gorges Mékrou	12 18N 02 37E		34		AR /OC	GKF	Renz (1983)
16.vi.1982	Mékrou	Gorges Mékrou	12 18N 02 37E		33		AR /OC	GKF	Renz (1983)
11.vi.1991	Mékrou	Gorges Mékrou	12 18N 02 37E		25		OCP	GKF	Fiasorgbor et al. (1991)
30.viii.1980	?Onana	Tributary of Mekrou	?	1	3		OCP	SEOM	Meredith (1980)
29.viii.1980	?Bani Barrage	?	?		1		OCP	SEOM	Meredith (1980)
TOTAL				**5**	**1200**				

(WHO, 2023a; 2023b), and verification was granted by WHO on 30 January 2025 (WHO, 2025a, 2025b).

Onchocerciasis in West Africa is transmitted by various members of the *S. damnosum* species complex. Eight members of this complex, termed cytospecies, were given species status by Vajime and Dunbar (1975) based on differences in the banding patterns of chromosomes isolated from their salivary glands. Subsequently, numerous other species and forms within the complex have been described. These have been listed by Adler (2025) and since they differ in their ecologies (Vajime and Dunbar, 1975) and their abilities to transmit onchocerciasis (Adler et al., 2010, Cheke and Garms, 2013), knowledge of their identities in a focus of onchocerciasis is important for understanding the epidemiology and for making control decisions, including when planning interventions for disease elimination and the eventual success of the planned interventions.

The objective of this study is to make a detailed assessment of all known identifications (most of which, including all references that are not emboldened in Table 1 and the data in Table 2, are previously unpublished) to confirm the cytospecies of the vector responsible for transmission of onchocerciasis in Niger, with respect to the WHO verification that transmission has been interrupted. No detailed assessment of the ecological requirements of the vectors in Niger is attempted here as such studies, including data on the cytospecies found in Niger but using data from elsewhere in their geographical ranges, have already been published (Cheke et al., 2017).

2. Methods

2.1. Study area

The only area of Niger known to support *S. damnosum* s.l. vector breeding sites includes the Niger river itself and tributaries flowing into it from its right bank (Balay, 1968; Prost et al., 1977; Davies et al., 1978). This is the study area (Fig. 1) and is bordered by Benin to the south, Burkina Faso to the west, Mali to the north and Nigeria to the south. It is drained by six river basins (listed north to south: Gorouol, Dargol, Sirba, Gouroubi, Dyamongou and Tapoa) which arise in Burkina Faso and flow eastwards across Niger into the Niger river, with one additional river in the south (Mékrou), which forms the international border between Benin and Niger. Annual rainfall in the study area varies from 800mm in the south to 400mm in the north (Balay, 1968; Bernus and Hamidou, 1980), with the rainy season lasting more or less from April to October (Bernus and Hamidou, 1980; Ojo, 1977). The rivers draining into the right bank of the Niger are seasonal (for example the Sirba river normally flows from June to November). 'Tributaries' entering from the left bank are only fossil valleys and intermittent watercourses that flow for very short periods following heavy rainfall (Prost et al., 1977; Bernus and Hamidou, 1980).

Most of Niger is underlaid by soft sedimentary rocks, except for the study area which is mostly underlaid by hard Precambrian rocks with some volcanic intrusions (Bernus and Hamidou, 1980), and it is these sorts of harder rocks which are more likely to produce white-water rapids and support vector breeding sites (Crosskey, 1981), such as in the Niger itself (Fig. 2). However, many of the *S. damnosum* s.l. breeding sites in rivers such as the Sirba are artificial, being fish traps formed of wooden stakes and lattices of sticks that create white water turbulence on their downstream sides (Figs. 3-5). According to White (1983) but using the less complicated and well-known nomenclature proposed by Keay (1953), the study area lies mostly within the Sudan Savannah vegetation zone, but with the northern part (containing the Gorouol and Dargol rivers, north of the Sirba river) in the Sahel vegetation zone.

2.2. Sources of information and database construction

Published and unpublished records of cytospecies identifications were compiled and are presented in Table 1, in which the data are

Table 2
Numbers of males, gravid females and non-gravid females of *Simulium damnosum* s.l. caught on Bellec plate traps in different periods during 1984 at Djongore. Two traps were operated simultaneously during the periods 4-10 and 8-12 October, which overlap. The right-hand column shows numbers of female *S. damnosum* s.l. caught per day at Garbey-Kourou during two-day catches within the same periods as the Bellec trap catches.

Period	Males	Gravid females	Non-gravid females	TOTAL	Flies per day	Flies per day at Garbey-Kourou
13-19 August		686	58	744	106.3	31.0
3-5 September		156	14	170	56.7	4.5
5-8 September	1	132	11	144	36	-
8-13 September	8	2241	92	2341	390.2	4.5
13-15 September		1446	44	1490	496.7	-
4-10 October		376	18	394	56.3 (2 traps)	0
8-12 October		200	38	238	47.6 (2 traps)	-
12-18 October		206	14	220	31.4	-
18-25 October		97	1	98	12.25	
2-8 November		36	1	37	5.3	
TOTAL	9	5576	291	5876		

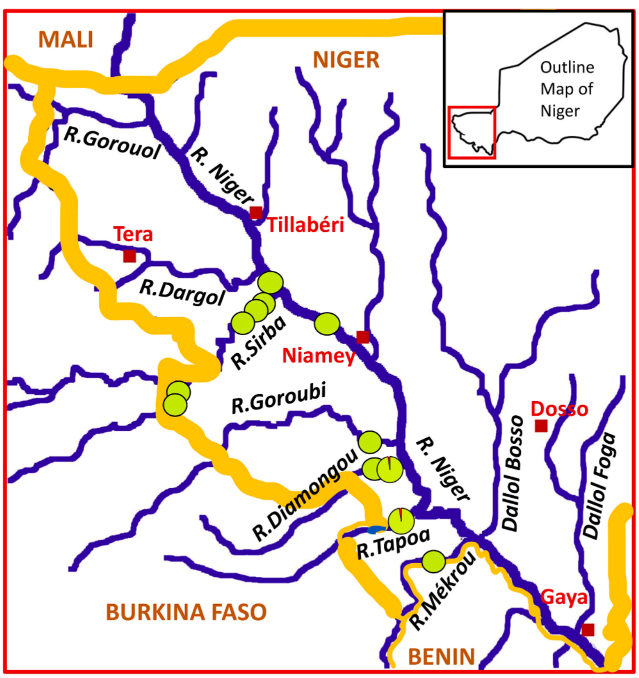

Fig. 1. Map of the study area showing main rivers (blue lines) and sites where *Simulium damnosum* s.l were collected (green circles). Open green circles indicate sites where only larvae of *S. sirbanum* were found; green circles with dashes indicate where larvae of *S. damnosum* s.str. were also found. Red squares indicate locations of main towns and the buff shading illustrates national borders. North is at the top of the map. Tillabéri's location approximates to the northern limit of *S. damnosum* in Niger, Gaya is the most southerly point of the distribution before the border with Benin and the distance between Tillabéri and Gaya is 332 km.

arranged north-south according to river basin. Fig. 1 shows the locations of these sites. The earliest records were the result of research carried out by ORSTOM-OCCGE, and most of the later publications were based on fieldwork carried out or sponsored by the OCP which ran from 1974 to 2002. Many of these data were obtained from OCP reports and/or from various documents held by the authors. Fieldwork in Niger during September 1984 to collect larvae and pupae of *S. damnosum* s.l. was conducted by RAC, assisted by S. A. Sowah and L. M. Sani, during helicopter prospections using a Hughes 500D helicopter of Viking Helicopters piloted by D. McLaughlin.

Whenever possible, the source documents for the identifications are indicated in Table 1 along with the name of the person(s) who collected the specimens and the name of the cytotaxonomist responsible for the identifications. In some cases, such as those reported by Meredith (1980), it was not possible to locate the positions of the sites referred to in reports so, given these doubts, such records have not been mapped in Fig. 1. The methods used for collection of larval specimens of *S. damnosum* s.l. from rivers and the subsequent dissection of the salivary glands for examination of the polytene chromosomes were fairly well standardized (Dunbar, 1972; Quillévéré, 1975; Boakye, 1988, 1993) with only minor variations between entomologists. The earliest cytotaxonomic identifications in Table 1 are from a sample collected in 1967, and the most recent identifications are from 1991. The criteria for the original identifications were based upon the seminal publications of Vajime and Dunbar (1975) and Quillévéré (1975) and these have been updated, where necessary, to conform to modern nomenclature according to Boakye (1993), Fiasorgbor and Cheke (1992), Post et al (2007) and Adler (2025), as noted in Table 1 and the Discussion section below. *S. sirbanum* now consists of five cytoforms, three of which occur in West Africa. Following Fiasorgbor & Cheke (1992), Post et al (2007) and Adler (2025) these are: (1) 'Sirba' Dunbar and Vajime (1971) (*damnosum* cytoform with males standard (st)/3 for the IS-3 inversion, females st/st: reported from Burkina Faso, Ghana, Ivory Coast, Mali, Niger, Nigeria and Togo); (2) 'Type III' Meredith et al. (1983) / Fiasorgbor & Cheke, 1992 (morphoform / cytoform with males st/3, females 3/3: Benin, Burkina Faso, Ghana, Nigeria and Togo) and (3) 'Type IV' Meredith, Cheke & Garms 1983 / Fiasorgbor & Cheke, 1992 (morphoform / cytoform with both males and females 3/3: Benin, Ghana, Niger and Togo). Both Type III and Type IV cytotypes were originally included within *S. sudanense* Vajime & Dunbar. However, the 'Type IV' form was the only one of these recognized cytoforms to be found in Niger by Fiasorgbor and Cheke (1992), who published a map showing where both types III and IV had been found.

In 1984 OCP staff placed Bellec plate traps (Bellec, 1976) at Djongore on the Gouroubi river to investigate numbers of adult *S. damnosum* s.l. in the area without using human landing catches. Made of shiny metal and coated with an adhesive, these sticky traps mimic turbulent river water and so attract mostly gravid females which can thus be anthropophilic or zoophilic insects, unlike human landing catches that only lead to captures of anthropophilic, blood-seeking, female insects. The traps were left in the field for varying periods up to a week at a time. Such traps, in combination with molecular means of identifying the sources of blood meals in the flies, have been used to detect zoophily in different members of the *S. damnosum* complex in Ghana (Lamberton et al., 2016), but the molecular techniques used were not available at the time of this study's collections.

3. Results

Collection data and identifications are shown in Table 1. These include data from the Mékrou gorge. The Mékrou river forms the border between Benin and Niger along some of its length, including along the gorge, so these data were also listed previously under Benin by Cheke et al. (2023).

Due to the seasonality of the rivers, no larvae were collected during

Fig. 2. *Simulium sirbanum* breeding sites in the Niger River at site N1, 25 km northwest of Niamey, 19 September 1984 (photo R. A. Cheke).

Fig. 3. Aerial view of large wooden fish trap traversing the Sirba river and creating breeding sites of *Simulium sirbanum*, Garbey-Kourou (site N2), 19 September 1984 (photo R. A. Cheke).

the months November to April. The total number of larvae collected and identified was 1205, all of which were identified as *S. sirbanum* except for five larvae of *S. damnosum* s.str. according to the standard criteria at the time. Vajime and Dunbar (1975) listed 5 *S. sudanense* amongst a 1977 collection from the Sirba river, but this taxon is now usually treated as a synonym of *S. sirbanum* for reasons given by Bedo (1977) and Vajime (1989). *Simulium sirbanum* occurs in at least four different cytoforms, three of which would have been identified as *S. sudanense* sensu Vajime and Dunbar (1975) (Fiasorgbor and Cheke 1992). Furthermore, the males of one of these forms, the northern form of *S. sirbanum* in which males have an IS-3/3 karyotype, are morphologically distinct, separable by the presence of a Type IV male scutal pattern (Cheke et al. 1987; Fiasorgbor and Cheke 1992).

The numbers of adult *S. damnosum* s.l. caught on the Bellec plate traps at Djongore are given in Table 2.

Fig. 4. R. A. Cheke, S. A. Sowah and local helpers collecting larvae and pupae of *Simulium sirbanum* from a wooden fish trap at site N3, Sirba river, 19 September 1984 (photo R. A. Cheke).

4. Discussion

The cytotaxonomic results confirm that *S. sirbanum* is predominant amongst the members of the *S. damnosum* complex found in Niger (Fig. 1, Table 1). Only five out of 1205 larvae identified were *S. damnosum* s.str., and so the evidence that *S. sirbanum*, very probably represented by the Type IV form, is the vector responsible for onchocerciasis transmission in Niger is overwhelming. This cytoform is, however, an inefficient vector of onchocerciasis since prior to control operations by the OCP, annual transmission potentials (ATPs) in Niger were in the 200-399 range (Philippon, 1987). Elsewhere such as near Bamako in Mali, where the only vector is also *S. sirbanum* but with Type III scutal patterns and thus a different form (Fiasorgbor and Cheke 1992), the ATP can be in excess of 800 (Philippon, 1987). In many other areas, *S. sirbanum* is often found sympatrically with *S. damnosum* s.str. and as the adult females of these species are indistinguishable morphologically, ascribing vector status to them separately is usually impossible. Nevertheless, some comparisons are possible since in the wet season (May to October) Renz & Wenk (1987) noted that 99% of members of the *S. damnosum* complex in the Tchollíré and Touboro regions of north Cameroon were *S. damnosum* s.str. At the Vina bridge site at Touboro, Renz (1987) noted an ATP of 2767 for 1976, based on dissections of 5239 flies (too few flies were dissected at Tchollíré to merit comparisons). Thus, on the basis of these data and those for *S. sirbanum* mentioned above, it is clear that *S. damnosum* s.str. is a much more efficient vector than *S. sirbanum*. In Togo, *S. squamosum* was estimated to have an ATP of 2000 (approximate total of monthly biting rate data depicted in Fig 2a of Cheke et al., 1992). Depending upon location, *S. squamosum* may sometimes be even more efficient (ATP of 9972) or less so (ATP of 523) in Cameroon (Enyong et al., 2006), with similar comparisons in terms of numbers of infective larvae per 1000 biting flies ranging from 19 to 449 for *S. squamosum* and 10 to 180 for *S. damnosum*/*S. sirbanum* in West Africa (Cheke & Garms, 2013). The low transmission rates of *S. sirbanum* in Niger may be partly attributable to their zoophilic tendencies.

There is circumstantial evidence that some or all of the forms of *S. sirbanum* occurring in Niger are not only anthropophilic, but are also highly zoophilic. *Simulium sirbanum* has been shown to be zoophilic in Mali (Séchan, 1984), and the capture of very high numbers of adult females on the Bellec traps (Table 2) also implies zoophily, since lower numbers were caught routinely by OCP vector collectors at Garbey-Kourou during the same period (Table 2). However, these results are not directly comparable, as the sites differed, and the decline in numbers at Garbey-Kourou coincided with a sudden rise in the level of the Sirba river (Cheke 1984), so it is possible that the fly numbers declined as a result of the breeding sites being eliminated by flooding. Even so, during the peak of the biting season in November the highest daily human landing catch at Garbey-Kourou in the previous season (1983) was about 340 flies per day (unpublished OCP data in Cheke 1984), which is less than the maximum rate of catches per day on the Bellec traps (496.7) at Djongore in 1984.

The data in Tables 1 & 2 show that the occurrence of *S. damnosum* s.l. in Niger is highly seasonal with flies only present from May until November, a pattern that is also reflected in the human landing catches at Garbey-Kourou in 1983 (unpublished OCP data in Cheke 1984). The seasonality is determined by the rainfall, with all of the relevant rivers being without flow in dry seasons, except the River Niger, but this has a very reduced flow then (Bernus and Hamidou, 1980) which may be unsuitable for vector breeding, although continuous breeding within microhabitats in this huge river is possible. This begs the question of how do the *S. damnosum* s.l. populations become re-established each wet season? Clearly, they could become re-established by females dispersing from perennial sites in the River Niger (if these exist), but it is also likely that flies move in from source rivers to the south or southwest, as these begin to flow and produce flies. Once some females have laid eggs at the start of a wet season, populations will build up rapidly since at the high temperatures of the water in the study area (approximately 30°C), larval development can be as short as 4 days and life-cycles take only 6.5 to 9 days (Séchan 1980).

Simulium sirbanum has been implicated in migrations in excess of 500 km (Garms et al. 1979; Baker et al. 1990) and the seasonal reinvasion of dry rivers in West Africa is usually the result of vectors carried on the monsoon winds, which blow from the southwest quadrant (i.e. from the south, southwest or west). With respect to the previously endemic areas

Fig. 5. Wooden fish trap creating breeding sites of *Simulium sirbanum*, Sirba river (site N4), 19 September 1984 (photo R. A. Cheke).

of Niger, this would mean from northwest Nigeria, northern Benin (and possibly Togo) and eastern Burkina Faso. *Simulium sirbanum* are present in the relevant parts of all these countries (Post et al., 2011; Cheke et al., 2023; Boakye et al., 1998) and in the absence of vector control an annual vector reinvasion into Niger is more or less inevitable. However, Burkina Faso now has no onchocerciasis in the east of the country (WHO-ESPEN, 2022), and the other countries have active programmes for the nationwide elimination of onchocerciasis transmission using Community Directed Treatment with Ivermectin which are expected to eliminate onchocerciasis transmission in due course, thus eliminating the threat of re-establishment of onchocerciasis transmission in Niger.

Limitations of our study include the lack of cytotaxonomic data after 1991 and the absence of direct evidence on the vector competence of the flies involved. Also, no molecular work was undertaken although, to date, no reliable molecular methods for identifying *S. sirbanum* and its cytoforms exist. If these become available, there will be opportunities for further studies on the ecology and vector efficiency of the various forms of *S. sirbanum* that occur in West Africa (Adler, 2025).

Author statement

None.

CRediT authorship contribution statement

Robert A Cheke: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Salissou Adamou Batchiri:** Writing – review & editing, Writing – original draft, Validation, Investigation. **Rory J Post:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Daniel A Boakye:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis.

Declaration of competing interest

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.

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Data availability

Data will be made available on request.

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