# ONCHOCERCIASIS AND *SIMULIUM* CONTROL IN THE VOLTA RIVER BASIN

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ABSTRACT. The World Health Organization Onchocerciasis Control Programme in the Volta River Basin of West Africa aims at reducing the transmission of *Onchocerca volvulus* Leukart, the cause of river blindness, to a level no longer dangerous to health by attacking the larval stage of the vector *Simulium damnosum* Theo. s. l. at its breeding sites in the rivers. The Programme covers an area of 700,000 sq. km. embracing 7 countries in which an estimated 1 million people are affected. Up to 14,000 km of rivers are treated with temephos by air using a fleet of 8 helicopters and 2 fixed-wing aircraft. The insecticide is applied at a dosage of 0.05 ppm/10 mins of river discharge. The effect of the applications is monitored on the ground by inspection of the rivers for aquatic stages and by assessing biting rates of black flies by making full day catches at some 270 points each week. After the 1st year of full scale control transmission rates in the center of the area are deemed satisfactory, but on the perimeters dangerous transmission continues. All evidence points to this being caused by flies invading the area from the south and west.

River Blindness or *onchocerciasis* is a filarial disease transmitted to man in West Africa by black flies of the *Simulium damnosum* Theo. complex. Light infections by the worm *Onchocerca volvulus* Leukart do not normally cause any grave symptoms, but heavy and repeated infections may lead to blindness caused by physical damage and the reaction of the eye to dead microfilariae.

The disease is widespread in Africa, but appears to be clinically more serious in the savanna areas (Anderson et al. 1974).

In heavily infected communities about 20% of persons, particularly males, over the age of 20 may have seriously impaired vision (Rolland & Balay 1969). These persons become a burden to communities already existing at subsistence level. As the productive output of the village falls the younger people and sometimes whole communities move away from rivers which they associate with blindness to more distant and less fertile lands (Hunter 1966, Rolland & Balay 1969).

The objective of the Onchocerciasis Control Programme is to reduce the risk of blindness in these river basins by lowerint the intensity of transmission to a level that does not lead to impaired vision, and to maintain this level for up to 20 years, that is, longer than the maximum life span of the adult worm (Anonymous 1973).

The Programme is therefore not just an insect abatement programme, but is linked with environmental, demographic and development projects whose combined objective is to make these poorly developed savanna communities more productive.

The main aspects of the Programme are thus:

1. Vector Control to reduce transmission,
2. Entomological Evaluation to assess the level of transmission,
3. Environmental Monitoring to assess effects on non-target organisms and the environment,
4. Epidemiological Evaluation to monitor the prevalence and intensity of the disease,
5. Coordination of Development Projects,
6. Research to find better methods of attack and possible chemotherapy.

This account deals mainly with the first 2 aspects as being of greatest interest to entomologists.

The present Programme covers an area of 700,000 km$^2$ (273,000 sq. miles) which is about equivalent to the area covered by the Great Lakes. It takes in parts of

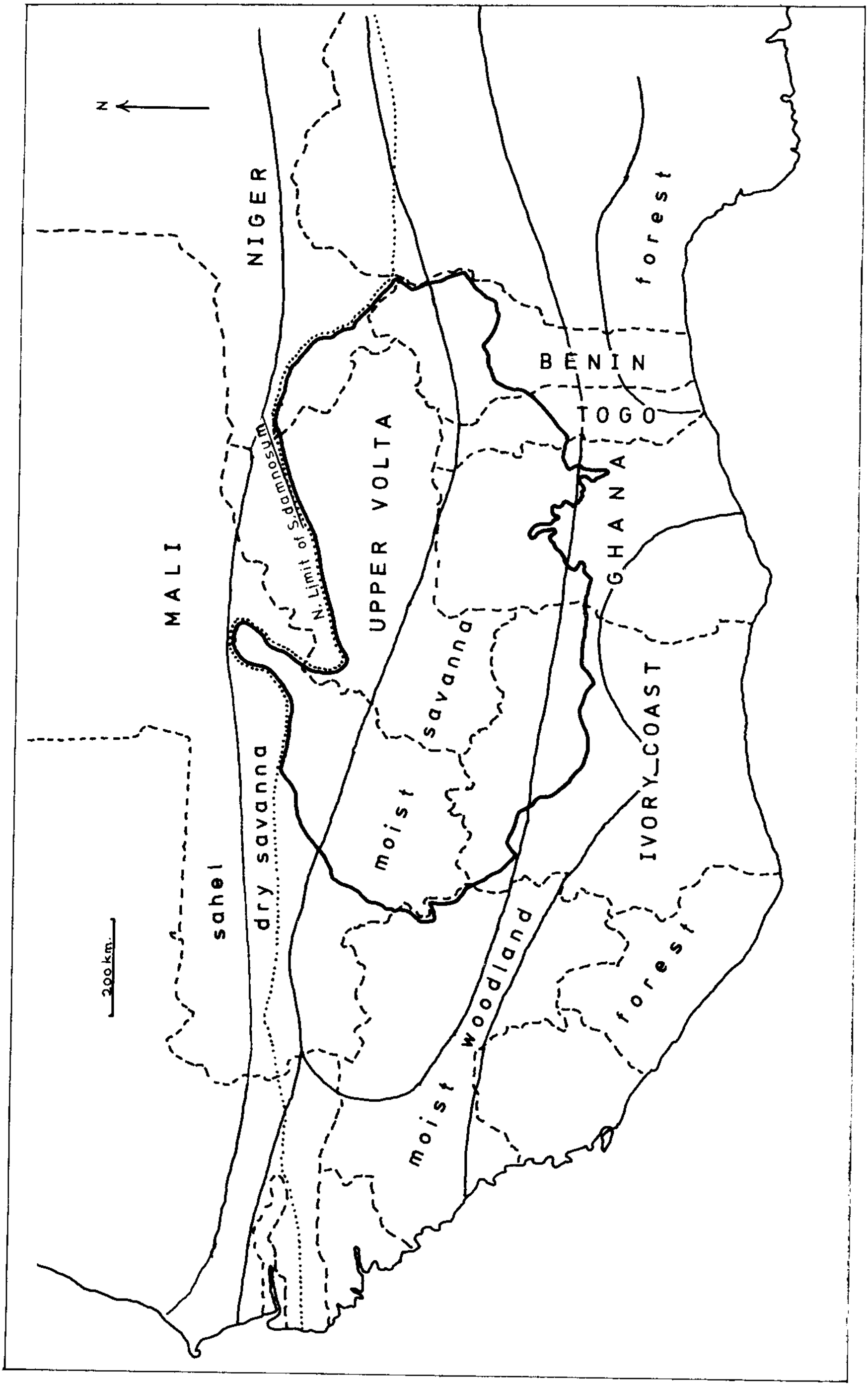


Figure 1. West Africa showing the position of the Onchocerciasis Control Programme Area in relation to the seven participating countries, vegetation zones and the northern limit of distribution of *S. damnosum*.

Upper Volta, Mali, Ivory Coast, Ghana, Togo, Benin and Niger. It is bounded on the east and west by the R.Niger and political frontiers, to the north by the natural northern limit of the vector, and to the south by tropical forest and the huge Volta Lake. (Figs. 1 and 2).

In this area live about 10 million people of whom it was originally estimated about 1 million have onchocerciasis and 70,000 have impaired vision or are blind from the disease. Because there is no effective mass chemotherapeutic cure or prophylaxis the disease must be attacked through its vector.

*Simulium damnosum* s.l. breeds in fast-flowing water and rapids of large streams and rivers. These rivers flow from one country to another and often form the frontiers between them. It has been known for some time that the fly may at times disperse up to 150 km from its breeding sites (Le Berre 1970, Walsh 1970), and it became obvious that the only way to attempt to control the fly would be to attack on an international scale. In this

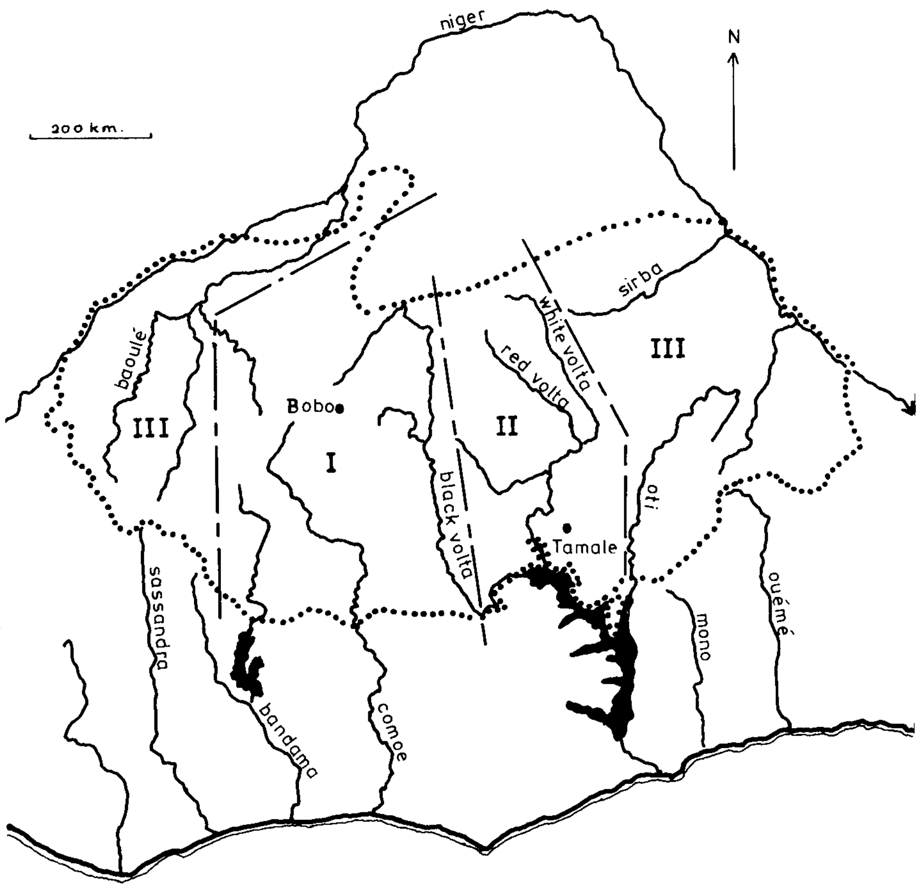


Figure 2. The Onchocerciasis Control Programme area showing the principal river systems, the phases of development (roman numerals) and the operations bases of Bobo Dioulasso and Tamale.

respect the O.C.P. is probably unique amongst vector control projects since it is truly international in concept. The Programme accepts complete responsibility for carrying out *Simulium* control in its area. All ground operations are carried out by staff directly employed by the Programme. All equipment, insecticides and vehicles are purchased by the Programme. The aerial operations are carried out by a contractor who provides aircraft and staff. Staff and vehicles have complete freedom of movement across frontiers just as the fly they are combatting.

The Project is financed by a special fund set up and administered by the World Bank. Funds are provided by a number of donor countries, which include the participating countries, as well as by UNDP, FAO and the World Bank itself. The executing agency is the World Health Organization.

The principles of attacking *Simulium* larvae by adding insecticide to river water are well known (Davies et al. 1968, Le Berre 1970, Walsh 1970) but when applications are to be made to thousands of kilometers of river in underdeveloped areas it becomes a fascinating entomological and logistical problem. First, all rivers had to be surveyed by helicopter in both dry and wet seasons, and all potential breeding sites verified by sampling and their position plotted on 1:200,000 scale maps. Because of the size of the area it was divided into 3 operational phases to enable work to be extended as trained staff and experience accumulated (Fig 2). Phase I commenced with preparations and surveys in 1974 and larviciding in February 1975. Phase II with surveys in 1975 and larviciding in May 1976. Phase III with surveys in 1976 and larviciding in March 1977.

Many of the treated rivers flow into man-made lakes. This, coupled with the use of river water for drinking and the very important fish industries connected with them make it imperative that no insecticidal build-up could be allowed to take place. A special formulation of temephos (Abate®) 20% emulsifiable concentrate was chosen because it gave a stable emulsion in river water under local conditions, was very effective and was biodegradable, breaking down within 3–4 days. Larviciding is carried out by an aerial contractor currently employing a fleet of 8 helicopters and 2 Pilatus Porter aircraft, operating from 2 bases at Bobo Dioulasso and Tamale (Fig. 2). Because the minimum time required for larval development is about 8 days the insecticide is applied weekly to all potential breeding sites at a dosage calculated to give a concentration 0.05 ppm temephos in 10 minutes of river discharge. Resulting from the breeding surveys which are continually being up-dated, the pilots are briefed each week and provided with maps on which each drop point is indicated, together with the quantity of temephos to be applied. This is recalculated each week from river gauge readings which are radioed to base prior to the briefing. Drops are made upstream of breeding sites either by an almost stationary helicopter, so that the insecticide can penetrate gaps in the tree canopy, or by moving at moderate speed to leave a line across the width of the river.

Large rivers are treated by Porter aircraft. The insecticide is projected backwards under pressure at a velocity equivalent to the forward speed of the aircraft so that it falls on the water in a compact mass. In 1977 the aircraft flew 6374 hr and dispensed 155,615 liters. (41,059 gal.) of insecticide covering a maximum of 14,000 km. of river per week. The area experiences a severe dry season of 4–7 months duration depending on latitude. This results in enormous variations in river discharge. At the height of the wet season, Sept-Oct., there may be 14,000 km. to be treated while in the dry season, Dec-April, this may be reduced to about one third. To provide fuel and insecticide for the aircraft 121 dumps are maintained at strategic points along the rivers and at bush airstrips to reduce ferry-flying to a minimum. The dumps are serviced by a fleet of 21 trucks.

The effect of the larviciding on non-target organisms is monitored by 3 teams based in the Ivory Coast, Upper Volta and Ghana. So far they report about 25% reduction in river invertebrates, but the community structure remains good. There are even several species of *Simulium* which survive the treatments. No adverse effect has been so far noticed with fish populations.

The efficacy of larviciding is assessed by estimating the biting densities of *S. damnosum* and by checking breeding sites and is carried out by the entomological evaluation teams. The area is divided into 7 sectors each supervised by an entomologist; and 24 sub-sectors, each supervised by a technician who also supervises 3–4 catching teams. (There is still no effective substitute for human bait.) They dissect a large proportion of the flies caught for age-grading and the presence of *Onchocerca* larvae. They make physical checks for larvae in the rivers and are responsible for reading the water gauges. These data are then transmitted to the operations bases by radio at the end of each week when they are analyzed and plotted on weekly maps from which the following week's larviciding treatment cycles are modified if necessary. To maintain this surveillance requires a staff of 9 entomologists, 29 technicians, 190 vector collectors, 170 drivers, 120 Land Rovers, 40 V.W. buses and other vehicles. In 1977 they travelled 6.8 million km.(4.3 million miles) and were repaired at 7 workshops.

Fly-catches are made at about 350 points, mostly associated with breeding sites. Of these about 270 are regularly visited. Catches are made for 11 hr per day (7am to 6pm). Flies are recorded by hr of capture and sent alive to the Sub-Sector laboratory for dissection within 24 hr of capture. As an example of the effort expended we can consider the statistics for a typical month. In May 1977 catches were made at 271 points by 85 teams working a total of 1653 man-days; 10,537 *S. damnosum* were caught, of which 8065 were dissected to find 6816 parous and 253 infective *Onchocerca* larvae.

Two broad criteria are being used to evaluate the progress of the control efforts. These are the Annual Biting Rate (estimated number of bites received by a person exposed for 11 hr per day for 365 days), and the Annual Transmission Potential (number of infective *Onchocerca* larvae carried by the same flies) (Duke 1968, Walsh et al 1978). Both can be easily calculated from the fly-catch data. An expert group meeting in Geneva has provisionally set safe levels of transmission at less than 100 3rd stage *O. volvulus* larvae per year or a biting rate of less than 1,000 per year.

A comparison of estimated annual transmission potentials at representative points pre-control and in the first year of complete control, 1977 (Fig. 3) shows that very few places were free from a dangerous level of transmission before control, but now most of the central area could be classed as habitable.

Of particular interest is the band of transmission persisting along the western, southern and eastern perimeters. Extensive field and laboratory research involving the morphology, physiology and cytotaxonomy of the flies caught in these areas now indicate very strongly that they originate from savanna habitats outside the programme area and invade during the wet season aided by the prevailing winds. Experimental larviciding of rivers to the southwest during 1976 and 1977 indicated 2 river systems as potential sources in this sector. We hope to confirm these findings in 1978. At present it looks as if flies are invading over distances up to 250 km, and for this reason we hope to extend the southern boundary of the programme to include all savanna habitats. This extension will commence in the Ivory Coast in 1978, and we hope to extend to the other countries later.

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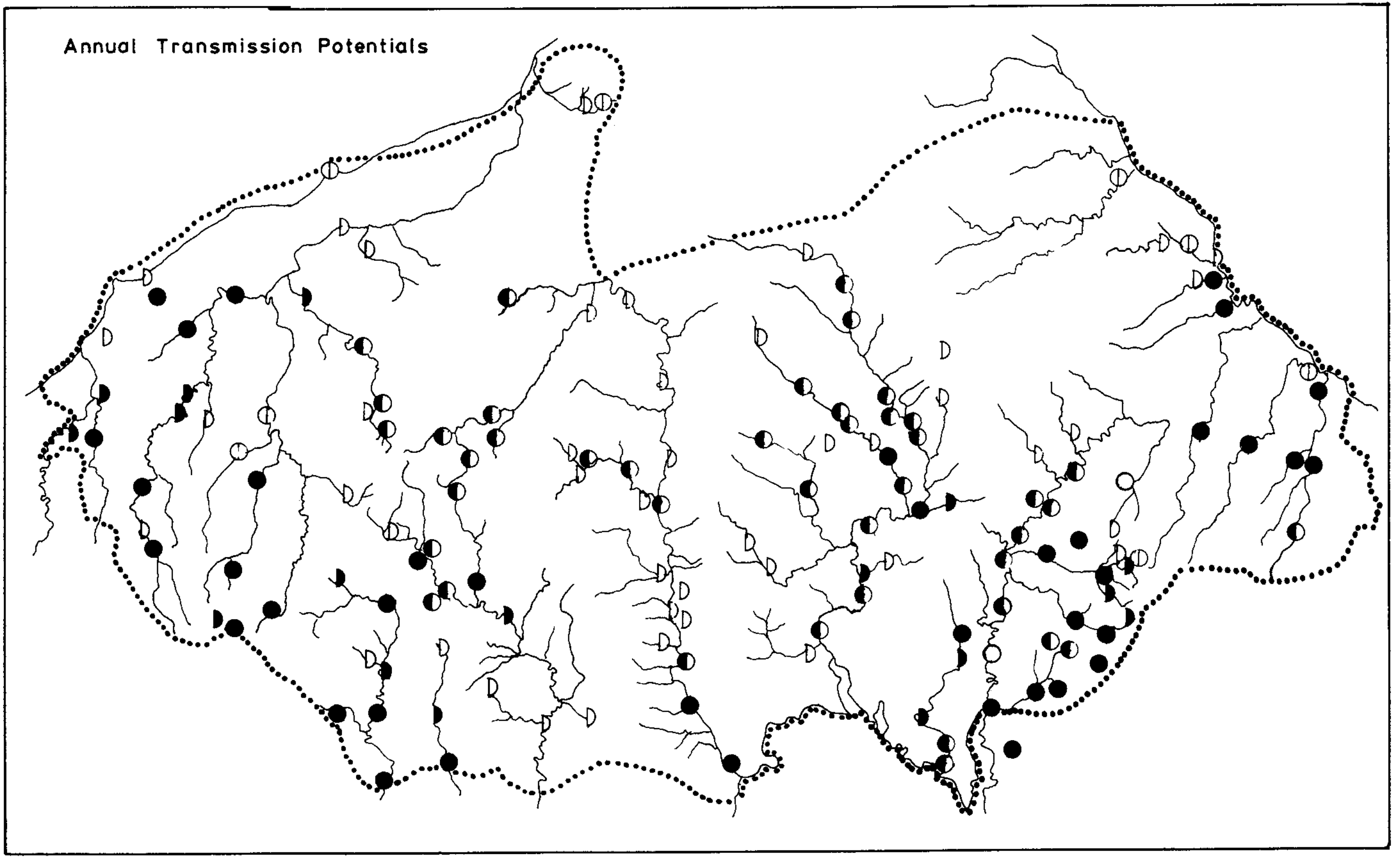


Figure 3. Annual transmission potentials of *Onchocerca volvulus* 3rd stage larvae pre-control (left half of circle) and in 1977 (right half of circle), at 147 representative catching stations. Black indicates a transmission potential of more than 100 *O. volvulus* larvae per year.

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