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Profile of eye lesions and vision loss: a cross-sectional study in Lusambo, a forest–savanna area hyperendemic for onchocerciasis in the Democratic Republic of Congo

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Summary

OBJECTIVE To determine baseline data regarding eye lesions and vision loss in five villages of Lusambo, an onchocerciasis-hyperendemic forest–savanna area in the Democratic Republic of Congo (DRC), in preparation of mass ivermectin distribution.

METHODS Five villages were selected by simple randomization. Through a cross-sectional design, 750 subjects were examined ophthalmologically. The eye examination included acuity visual measurement, slit-lamp examination, ophthalmoscopy, intraocular pressure measurement, and visual field assessment by the Wu–Jones test.

RESULTS There was a high prevalence of onchocerciasis-related eye lesions compared with non-onchocercal lesions. Chorioretinitis (20%) was the most frequent disease, others were punctate keratitis and microfilariae in the anterior chamber in equal frequency (13.8%), white intraretinal deposits (10.4%) and iridocyclitis (8%). Vision loss was discovered in 8.5% of the subjects, of whom 0.5% had bilateral blindness, 2.2% had monocular blindness and 5.7% had visual impairment. Vision loss was mostly caused by onchocerciasis-related diseases, especially those affecting the anterior segment of the eye.

CONCLUSION Features of ocular onchocerciasis usually described in forest and savanna areas were both found in this forest–savanna zone of the DRC.

keywords onchocerciasis, eye lesions, vision loss, forest–savanna, Lusambo, Democratic Republic of Congo

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Introduction

The Democratic Republic of Congo (DRC) is a large country (2.345 million km^2), situated in Central Africa. Although no up-to-date census has been carried out since the 1980s, the population is an estimated 50–55 million, with an annual rate of population increase of 3.2%. About 48% are under the age of 15; life expectancy is estimated at 50 years for men and 53 years for women. Approximately 65% of the population live in rural areas. The country has a high literacy rate: 84% for men and 61% for women. The gross national product was US$200 per head in 1985, but has dramatically fallen because of grave economic deterioration during the last 10 years resulting from political instability, poor management of available resources and war. Almost the whole country is endemic for onchocerciasis (Fain & Hallot 1965; Maertens 1978, 1990).

Onchocerciasis is a disease of great public importance in view of the medical and socio-economic problems associated with it (Duke 1990; Workneh *et al.* 1993; Evans 1995; WHO 1995). According to the WHO (1995), 123 million people are at risk of contracting the disease, 18 million people are already infected in Africa and Central and South America, of whom about 270 000 (40 000 in the DRC) (Murray & Lopez 1996) are blind and 500 000

severely visually impaired. The disease has been largely controlled in most parts of West Africa following the implementation of the Onchocerciasis Control Programme (OCP) in 1974. This programme was launched to eliminate the disease first in seven and then in 11 West African countries by aerial application of larvicides to the breeding sites of backflies. After 13 years of vector control, the disease transmission fell sharply in these countries. Consequently, microfilariae were no longer seen in the eye, and there were no new cases of onchocerciasis-related eye lesions and blindness. Because of the high effectiveness and safety of ivermectin, and also because the manufacturer agreed to provide it free of charge for however long it would be needed, the WHO introduced it as part of the OCP. This programme has been a success (WHO 1997; Boussinesq & Hougard 1998), and in October 1999 the WHO officially celebrated the elimination of onchocerciasis in most West African countries.

In late 1995, the WHO decided to launch the African Programme for Onchocerciasis Control (APOC) (Remme 1995) to extend the gain of OCP to 11 new countries, one of which is the DRC. To date, however, the APOC is applied in 19 countries. APOC, unlike OCP, is based on ivermectin distribution by a community directed strategy (Remme 1995; Dadzie 1997). Its ultimate goals are to treat the remaining 60 million people at risk of contracting the disease, and to eliminate onchocerciasis as a public health problem in Africa by 2007.

In the DRC, three sites were selected for the evaluation of the impact of APOC activities: Lusambo (Eastern Kasaï province), Inga (Bas-Congo province) and Uélé (Eastern province). So far, we have surveyed Lusambo and Inga. This paper presents the baseline data of the first cross-sectional study conducted in Lusambo, in preparation for mass ivermectin distribution.

Materials and methods

Study area

This study was conducted in five villages (Camp Scieur, Lomena, Mushitu, Olamba and Tshinga), all situated in the health zone of Lusambo, Sankuru district and Eastern Kasaï region. They are all located on the right side of the Sankuru river 12–16 km from Lusambo City (Fig. 1). This area is well known as hyperendemic for onchocerciasis (Fain & Hallot 1965; Wery *et al.* 1976; Maertens 1990; Law *et al.* 1998; Mandiangu & Kayembe 1999), as the prevalence of people with nodules is greater than 39%. Most people live by subsistence farming, the main crop being rice. Maize, cassava, peanuts, plantains and palm oil are also widely available. The climate is tropical with two variations: the rainy season from September to April, and the dry season from May to August. The vegetation is primary forest furrowed by several streams and degraded by several savanna areas. From Lusambo, the best way to reach villages is by boat. Neither eye care services nor electricity exist there. This area was chosen for the study for the following reasons: (1) it is hyperendemic for onchocerciasis, (2) it is reasonably accessible throughout the year, and (3) it has never seen mass distribution of ivermectin.

Sample size determination

The specific aims of the programme being to estimate the prevalence of onchocercal skin and eye lesions by age, it is expected that the prevalence of onchocercal skin lesions fall from about 15% to 10% and the prevalence of microfilariae in the anterior chamber from 10% to 5%. Using a drop in prevalence rate of 10% resulting from the activities, the APOC has estimated that a sample of 750 inhabitants was sufficient at each study site of the programme. For the ophthalmological evaluation, only people aged 10 and older were included in the study. All these people were well identified by the pre-evaluation census.

Survey procedure

The study was conducted during the dry season, from 17 July to 1 August 1998. Prior to the clinical (ophthalmological and dermatological) examination, socio-economic and entomological (Traore *et al.* 1998) surveys were conducted. The aim of the sociological survey was to arrange for an exhaustive census of the study site and to inform and mobilize the population to prevent problems usually associated with this kind of study, such as suspicion. One day after the arrival of the team in Lusambo, the local administrative and health authorities were contacted, and the villages were selected by simple random sampling. Village leaders were especially asked to inform heads of families about the forthcoming visit and to ask them to be present on the day of examination with all eligible family members. The team was based in Lusambo city and went every morning to the villages by boats. Taking the village Olamba as the starting point, all householders aged 10 and above, and living in houses with odd numbers, were examined consecutively until the number of 750 was reached.

The study was approved by the Ministry of Health of the DRC, and verbal consent was obtained from all participants. All equipments and electricity supply units were brought from Kinshasa by plane.

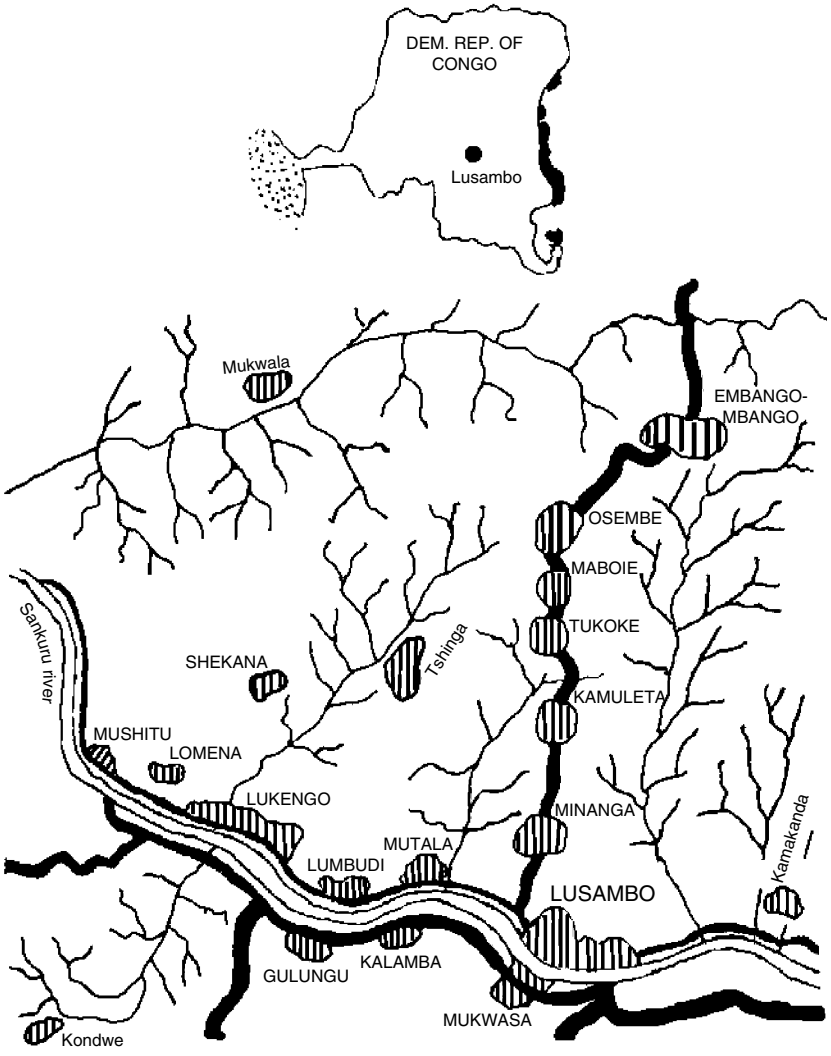

Figure 1 Map of the study area.

Ophthalmological examination

A total of 750 subjects were invited and underwent an ophthalmological examination. All participants underwent visual acuity (VA) measurement and the visual field (VF) test, while 375 randomly selected members of this group had a complete examination. The VA was measured on each eye separately using an illiterate E-chart at 6 m in broad daylight, with the source of light behind the subject. A pinhole was used when VA was <6/18. Vision loss (blindness, monocular blindness and visual impairment) was defined according to the standard classification (WHO 1980). The examination of the anterior segment was performed using a Haag Streit 900 slit-lamp after head positioning of subjects for at least 2 min.

The fundus was examined by direct ophthalmoscopy after pupil dilatation with a mixture of 0.4% tropicamide and 10% phenylephrine. Intraocular pressure was measured by applanation in people with cup-to-disc ratio of 0.5 or greater. The VF test was performed with the Wu–Jones test according to the following procedure: a series of vertical lines are displayed on the computer screen. As preliminary training, the subject, who is 40 cm away from the screen, is asked whether he sees them and if so to count them. He is then asked to watch the lines and to press a buzzer as soon as he perceives movement of any of the lines. When the examiner is certain that the subject has understood the test, one eye is occluded and the subject fixes with the open eye on a central white target on the screen all the time, and presses the buzzer whenever he sees

any movement of the lines. At the end of the test, which lasts about 2.2 min, the result is displayed on the screen. This is registered on the hard disk before examining the other eye in the same way. Onchocerciasis was diagnosed in the presence of typical onchocercal signs in the anterior and/or posterior segment of the eye. Open-angle glaucoma was defined as intraocular pressure above 21 mmHg in the presence of optic disc cupping. Fluoangiography, gonioscopy and colour tests were not performed.

At the end of each day's work, when back in Lusambo, the results of the examination were reviewed by the team for completeness and exactness. Any arising question was resolved by consensus.

Data management

During the examination, the results were recorded on printed forms and all data entered into a Dell microcomputer afterward, using an EPI INFO database.

Results

Demographical characteristics of the participants

A total of 750 individuals attended the pre-treatment survey, 52.4% were male. Their distribution in age groups is displayed in Table 1. Most (65.8%) were less than 40 years old.

Ocular lesions

Table 2 shows the prevalence of ocular lesions found in the 375 subjects who underwent a complete eye examination. Among onchocerciasis-related eye lesions, chorioretinitis (20.4%) was the most prevalent condition. The other frequent lesions were punctate keratitis and microfilariae in the anterior chamber disclosed in 13.8% each, white intraretinal deposits (10.4%) and iridocyclitis (8%). However, anterior segment lesions were more prevalent than those posteriorly located. Among lesions thought not secondary to onchocerciasis, cataract, disclosed in 31 (8.3%) patients, was the most frequent condition. When trying to compare the prevalence of onchocerciasis-related eye lesions in different age groups, we particularly noticed that lesions of the anterior segment appeared earlier in life and decreased with age, except sclerosing keratitis for which prevalence increased with age. In contrast, posterior segment lesions showed an increasing evolution with increasing age. A correlation was found between the number of white intraretinal deposits and the severity of chorioretinitis. Ten of the 12 subjects who had sclerosing keratitis were females.

Table 1 Distribution of participants in age groups

Age groups (years)	*N* (%)*	*N* (%)†
10–19	93 (25)	190 (25.3)
20–29	73 (19.4)	144 (19.2)
30–39	81 (21.6)	160 (21.3)
40–49	69 (18.4)	140 (18.7)
50–59	25 (6.6)	56 (7.5)
≥60	34 (9)	60 (8)
Total	375 (100)	750 (100)

* Number of subjects who underwent a complete eye examination.
† Total number of participants.

Table 2 Prevalence of ocular lesions

	N (%)
Onchocercal lesions	
Anterior segment	163 (43.4)
Punctate keratitis	52 (13.8)
MFAC	52 (13.8)
Iridocyclitis	30 (8)
MFC	17 (4.5)
Sclerosing keratitis	12 (3.2)
Posterior segment	130 (34.7)
Chorioretinitis	76 (20.4)
White intraretinal deposits	39 (10.4)
Optic atrophy	9 (2.4)
Open-angle glaucoma	6 (1.6)
Subtotal	293 (78.1)
Non-onchocercal lesions	
Age-related cataract	31 (8.3)
Open-angle glaucoma	6 (1.6)
Phtisis bulbi	2 (0.5)
Subtotal	39 (10.4)
No lesions	43 (11.5)
Grand total	375 (100)

MFAC, microfilariae in the anterior chamber; MFC, microfilariae in the cornea.

Prevalence of vision loss

The overall prevalence of vision loss increased with age and ranged from 0.5% in people aged 10–19 years to 35% in those aged at least 50 years. The prevalence of blindness, monocular blindness and visual impairment was 0.5%, 2.2% and 5.7%, respectively. This means that a total of 64 subjects, as 8.5% of the participants, had various degrees of vision loss. Among these, people aged 50 years and older (64%) were most affected (Table 3). It is worth stressing that the group with full examination showed the same results as the one with partial examination.

Table 3 Distribution of prevalence of low vision in age groups

Age groups (years)	*N*	BB *N* (%)	MB *N* (%)	VI *N* (%)	Total *N* (%)
10–19	190	–	1 (0.5)	–	1 (0.5)
20–29	144	–	1 (0.7)	–	1 (0.7)
30–39	160	–	1 (0.6)	7 (5.5)	8 (5)
40–49	140	–	4 (2.8)	9 (6.4)	13 (9.3)
50–59	56	2 (3.5)	3 (5.3)	15 (26.7)	20 (35.7)
≥60	60	2 (3.3)	7 (11.6)	12 (20)	21 (35)
All ages	750	4 (0.5)	17 (2.2)	43 (5.7)	64 (8.5)

BB, bilateral blindness; MB, monocular blindness; VI; visual impairment.

Causes of vision loss

Among the 64 subjects with different degrees of vision loss, onchocercal pathologies were thought to be the cause in 20 (31.2%) of them while non-ochocercal conditions were incriminated in the remaining 68.8% of subjects (Table 4). Of the four cases of bilateral blindness, only one (iridocyclitis) was attributable to onchocerciasis. The other three cases were due to age-related cataract (two cases) and primary open-angle glaucoma (one case). Corneal scars (23.5%) and aphakia (17.6%) were the commonest causes of monocular blindness. The main causes of visual impairment were age-related cataract (37.2%), onchocercal anterior segment diseases (18.6%), refractive errors and onchocercal posterior segment diseases in equal prevalences (11.6%). However, visual impairment was mainly caused by non-onchocercal diseases (62.8%). Among onchocercal lesions, vision loss was more frequently caused by anterior segment diseases. None of the participants had blindness attributable to onchocercias-induced posterior segment disease.

Discussion

The overall prevalence of eye lesions was 88.5%, a figure much higher than those previously reported in Nigeria (Abiose *et al.* 1994; Umeh *et al.* 1996). Among onchocercal lesions, chorioretinitis, punctate keratitis, microfilariae in the anterior chamber and white intraretinal deposits were the most frequent. This pattern differs from that found in other similar ecological areas (Newland *et al.* 1991; Umeh *et al.* 1996). In addition, prevalence of chorioretinal diseases, microfilariae in the anterior chamber and punctate keratitis is lower than in those countries. The strong association between punctate keratitis and the number of microfilariae in the cornea previously reported in several areas (Remme *et al.* 1989; Newland *et al.* 1991) was not found in the present study. We believe this finding

Table 4 Causes of low vision

Causes	BB *N* (%)	MB *N* (%)	VI *N* (%)	Total *N* (%)
Non-onchocercal				
Cataract	2 (50)	2 (11.8)	16 (37.2)	20 (31.2)
Open-angle glaucoma	1 (25)	1 (5.9)	3 (7)	5 (7.8)
Phtisis bulbi	–	2 (11.8)	–	2 (3.1)
Corneal scar	–	4 (23.5)	2 (4.6)	6 (9.4)
Aphakia	–	3 (17.6)	–	3 (4.7)
Optic atrophy	–	2 (11.8)	1 (2.3)	3 (4.7)
Refractive errors	–	–	5 (11.6)	5 (7.8)
Subtotal	3 (75)	14 (82.3)	27 (62.8)	44 (68.8)
Onchocercal				
Anterior segment diseases	1 (25)	2 (11.8)	8 (18.6)	10 (17.1)
Posterior segment diseases	–	1 (5.9)	5 (11.6)	6 (9.4)
Both segment diseases	–	–	3 (7)	3 (4.7)
Subtotal	1 (25)	3 (17.7)	16 (37.2)	20 (31.2)
Grand total	4 (100)	17 (100)	43 (100)	64 (100)

BB, bilateral blindness; MB, monocular blindness; VI, visual impairment.

lends indirect support to the immunological origin of punctate keratitis rather than the direct effect of cytotoxic molecules released from the parasite (Pearlman *et al.* 1997; Hall & Pearlman 1999). The prevalence of sclerosing keratitis (3.2%) although a bit low, is comparable with that reported elsewhere (Newland *et al.* 1991; Umeh *et al.* 1996). When comparing the prevalence of this condition in men and women, we found that women were more affected than men. A similar finding has been reported by others (Anderson *et al.* 1974; Newland *et al.* 1991). The reason for such a difference is unclear, as both men and women are exposed in the same way. It has been hypothesized (Anderson *et al.* 1974) that in women, hormones would play a protective role during their productive age. So far, it has not been confirmed. However, women have a higher life expectancy than men.

Apart from sclerosing keratitis, for which prevalence increased with age, the prevalence of anterior segment lesions decreased gradually with age. The inverse was observed for posterior segment lesions. These findings are in accordance with previous reports in this region (Wery *et al.* 1976; Brown & Shannon 1989) and in Liberia (Newland *et al.* 1991).

White intraretinal deposits occurred in 10.4%, a prevalence twice lower than that found in Liberia by Newland *et al.* (1991). They consist of small and well-delimited lesions disseminated throughout the retina, without any predilection. Their oncho origin, first hypothesized by Semba *et al.* (1990), is questionable and needs to be confirmed by further studies. People with severe chorioretinitis had a great number of white intraretinal deposits. It is unclear whether or not a steady relationship exists between the two types of lesions. Semba *et al.* (1990) reported a finding, somewhat different to ours, in that white intraretinal deposits occurred in great numbers in individuals with extensive pigment epithelial and chorioretinal atrophy. Newland *et al.* (1991), however, found a correlation between this lesion and punctate keratitis. Furthermore, he hypothesized that white intraretinal deposits would have an inflammatory aetiology. The findings of the present study are in accordance with previous published reports (Umeh *et al.* 1996; Umeh 1999) indicating a high prevalence of onchocerciasis-related ocular diseases in forest–savanna areas. A high rate of ocular morbidity, which is commonly found in savanna areas (Anderson *et al.* 1974; WHO 1987), was found in this forest–savanna zone.

Previous studies reported 8% (Wery *et al.* 1976) and 20% (Hissette 1931) of blindness, respectively, in the north and the western parts of Lusambo, and 0.5% in this area. The following estimates have been reported from other African areas: 0.4%–1.9% in Liberia (Frentzel-Beyme 1973, 1975; Newland *et al.* 1991), 1.3% in Sierra Leone (Witworth *et al.* 1993), 2.2% in the Central African Republic (Schwartz *et al.* 1997), 3.3%–5.4% in Nigeria (Abiose *et al.* 1994; Umeh *et al.* 1996; Umeh 1999) and 2% in Cameroon (Anderson *et al.* 1974). The onchocerciasis blindness rate in forest areas is low (Anderson *et al.* 1974; Dadzie *et al.* 1990). We believe an additional number of blind subjects would have been detected if the VF had been tested by Goldmann perimetry. Indeed, the Wu–Jones test recommended by the WHO – APOC is not accurate for the evaluation of the VF. We observed that it has a low validity and a low negative predictive value. The rate of false negative results seems high. For these reasons, studies to assess the sensitivity, positive and negative predictive values of this test are really needed.

Previous reports indicate that most onchocercal blindness cases in forest–savanna areas are caused by posterior segment lesions, especially optic and chorioretinitis. It is surprising that no case of blindness attributable to posterior segment lesions was found in this area, despite the high rate of onchocercal pathologies encountered. In contrast, most cases of vision loss were caused by anterior segment pathologies, a feature usually found in savanna zones (Anderson *et al.* 1974).

Conclusion

Apart from the low prevalence of vision loss, especially blindness, the findings of this study confirmed data of previous reports regarding eye lesions in Lusambo. Furthermore, both features of onchocerciasis in savanna and forest areas were found in this forest–savanna zone.

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References

Abiose A, Murdoch I, Babalola O *et al.* (1994) Distribution and etiology of blindness and visual impairment in mesoendemic onchocercal communities, Kaduna State, Nigeria. *British Journal of Ophthalmology* **78**, 8–13.

Anderson J, Fuglsang H, Hamilton PJS & Marshall TF de C (1974) Studies on onchocerciasis in the United Cameroon Republic. II. Comparison of onchocerciasis in rain-forest and Sudan–Savanna. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **68**, 209–221.

Boussinesq M & Hougard JM (1998) La lutte contre l'onchocercose en Afrique: aspects actuels. *Médecine Tropicale* **58**, 285–296.

Brown R & Shannon R (1989) Prevalence, intensity and ocular manifestations of *Onchocerca volvulus* infection in Dimbelenge, Zaïre. *Annales de la Societe Belge de Medecine Tropicale* **69**, 137–142.

Dadzie KY (1997) Onchocerciasis control: the APOC strategy. *Africa Health* **3**, 13–15.

Dadzie KY, Remme J, Baker RHA, Rolland A & Thylefors B (1990) Ocular onchocerciasis and intensity of infection in the community. III. West African rain forest foci of the vector Similium sanctipauli. *Tropical Medicine and Parasitology* **41**, 376–382.

Duke BO (1990) Human onchocerciasis – an overview of the disease. *Acta Leidensia* **59**, 9–24.

Evans TG (1995) Socioeconomic consequences of blinding onchocerciasis in West Africa. *Bulletin of the WHO* **73**, 495–506.

Fain A & Hallot R (1965) Répartition de l'Onchocerca volvulus Leuckart et ses vecteurs dans le bassin du Congo et les régions limitrophes. *Koniklijkeacademie voor overzeese Wesenschappen, klasse voor natuur-en geneeskundige westenschappen Brussels* **XVII-1**, 1–86.

Frentzel-Beyme R (1973) The prevalence of onchocerciasis and blindness in the population of the Bong Range, Liberia. *Tropical Medicine and Parasitology* **24**, 339–357.

Frentzel-Beyme R (1975) Visual impairment and incidence of blindness in Liberia and their relation to onchocerciasis. *Tropical Medicine and Parasitology* **26**, 469–488.

Hall LR & Pearlman E (1999) Pathogenesis of onchocercal keratitis (River Blindness). *Clinical Microbiology Reviews* **12**, 445–453.

Hissette J (1931) Sur l'existence d'affections oculaires importantes d'origine filarienne dans certains territoires du Congo. *Annales de la Societe Belge de Medecine Tropicale* **11**, 45–46.

Law PA, Ngandu ON, Crompton P *et al.* (1998) Prevalence of *Onchocerca volvulus* nodules in the Sankuru River Valley, Democratic Republic of the Congo, and reliability of verbal assessment as method for determining prevalence. *American Journal of Tropical Medicine and Hygiene* **59**, 227–230.

Maertens K (1978) Distribution d'*Onchocerca volvulus* en République du Zaïre. *Médecine de l'Afrique Noire* **26**, 78–84.

Maertens K (1990) Onchocerciasis in Zaïre. *International Journal of Ophthalmology* **14**, 181–188.

Mandiangu ML & Kayembe LD (1999) L'onchocercose en République Démocratique du Congo. Prévalence et géorépartition. *Congo Médical* **9**, 602–607.

Murray CJL & Lopez AD (1996) *The Global Burden of Disease. A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Havard University Press, Cambridge.

Newland HS, White TA, Greene BM, Murphy RP & Taylor HR (1991) Ocular manifestations of onchocerciasis in a rain forest area of West Africa. *British Journal of Ophthalmology* **75**, 163–169.

Pearlman E, Lass JH, Bardenstein DS *et al.* (1997) IL-12 exacerbates helminth-mediated corneal pathology by augmenting cell recruitment and chemokine expression. *Journal of Immunology* **158**, 827–833.

Remme JHF (1995) The African programme for onchocerciasis control: preparing to launch. *Parasitology Today* **11**, 403–406.

Remme J, Dadzie KY, Rolland A & Thylesfors B (1989) Ocular onchocerciasis and intensity of infection in the community. 1. West African savanna. *Tropical Medicine and Parasitology* **40**, 340–347.

Schwartz EC, Huss R, Hopkins A *et al.* (1997) Blindness and visual impairment in a region endemic for onchocerciasis in the Central African Republic. *British Journal of Ophthalmology* **81**, 443–447.

Semba RD, Murphy RP, Newland HS, Awadzi K, Greene BM & Taylor HR (1990) Longitudinal study of lesions of the posterior segment in onchocerciasis. *Ophthalmology* **97**, 1334–1341.

Traore S, Mandiangu ML, Kayembe LD, Lapika LD, Mpoudi NE & Boussinesq M (1998) Capacités vectrices naturelles de Similium neavei et risque de transmission d'*Onchocerca volvulus* en saison sèche dans la région de Lusambo, Kasai Oriental, République Démocratique du Congo. *OCCGE-Informations* **110**, 36.

Umeh RE (1999) The causes and profile of visual loss in an onchocerciasis endemic forest–savanna zone in Nigeria. *Ophthalmic Epidemiology* **6**, 303–315.

Umeh RE, Chijioke CP & Okonkwo PO (1996) Eye disease in an onchocerciasis endemic area of forest–savanna mosaic region of Nigeria. *Bulletin of the WHO* **74**, 95–100.

Wery M, Maertens K, Wery-Paskoff S & Fain S (1976) Contribution à l'étude de l'infestation par *Onchocerca volvulus* dans la région de Lusambo (Kasaï Oriental, Zaïre). Aspects parasitologique, ophtalmologique et immunologique. *Annales de la Societe Belge de Medecine Tropicale* **56**, 95–124.

Witworth JAG, Gilbert CE, Mabey DM, Morgan D & Foster A (1993) Visual loss in an onchocerciasis endemic community in Sierra Leone. *British Journal of Ophthalmology* **77**, 30–32.

Workneh W, Fletcher M & Olwit G (1993) Onchocerciasis in fields workers at Baya Farm, Teppi Coffee Plantation Project, southwestern Ethiopia: prevalence and impact on production. *Acta Tropica* **54**, 89–97.

World Health Organization (1980) *Methods of Assessment of Avoidable Blindness*. WHO, Geneva, p. 54.

World Health Organization (1987) Expert committee on onchocerciasis. Third Report. *Technical Report* **752**.

World Health Organization (1995) Onchocerciasis and its Control. *Technical Report* **852**.

World Health Organization (1997) *Twenty years of onchocerciasis control in West Africa. Review of the Work of the Onchocerciasis Control Programme in West Africa*. WHO, Geneva.

