

A Scientific Causal Analysis Of River Blindness: A Type Of Onchocerciasis Specifically Found In Northern Nigeria.

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Abstract: River blindness is known internationally and it is of great concern even to the World Health Organization. Experts have also worked greatly to unveil the secrets about its real causes in different parts of the world. An aspect of its cause that seems to have worried researchers in Nigeria is that the same vector does not produce the same disease in the south as is seen in the Northern part of Nigeria. This study was therefore determined to use scientific analysis to find the factors that helps the occurrence of River Blindness in the Northern part of Nigeria, whereas the Southern Nigeria which also harbours the *S. damnosum* vector, (carrying *O. volvulus* parasite, the nematode related to any onchocerciasis type of disease), does not have the disease. Scientific analysis is the method adopted for this study, coupled with some descriptive survey. All results were subjected to statistical interpretation to reveal the result in a simplified form. One of the finding is that a variety of the Onchocerca parasite might exist apart from the famous *O. volvulus*. This coupled with some other human genetic factors, differently found within the north-south divide might be the causal factor.

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1. Introduction

Onchocerciasis or river blindness results from infestation by the nematode *Onchocerca volvulus*, characterized by eye affections and skin lesions with severe troublesome itching. It is a chronic, communicable, slowly progressive, parasitic disease which has being rated as the second-leading infectious cause of blindness worldwide with approximately 500,000 people blind annually [Mboera, 2010; WHO, 2011]. The initial infestation often occurs in childhood, and many of the affected individuals remain asymptomatic for long periods. In recent years, the World Health Organization's Onchocerciasis Control Program has successfully reduced the prevalence of onchocerciasis by interfering with the transmission of the parasite and by mass population treatment in the regions at risk. Despite these laudable efforts, the socioeconomic burden resulting from the disabilities caused by onchocerciasis, however, remains enormous (Workneh et al., 1993; Kale, 1998). Onchocerciasis is a disease of the warm tropical environment in which the flies that carry it live under conditions favourable for their development all year round (Crosskey, 1990, Akinboye et al., 2010; Keenan et al., 2013). It is transmitted by different species of *Simulium* (blackfly) in different parts of the world where the disease is endemic. In West Africa, the disease is transmitted by *Simulium damnosum* complex, which is made up of about 26 cytospecies some of which are *S. damnosum s. s.*, *S. sirbanum* found in Sudan and Guinea savannas,

S. squamosum and *S. sanctipauli* in the forest zone (Boakaye, 1993; Mafuyai et al., 1996). These flies breed mainly in fast flowing streams and rivers. Species of *Simulium neavei* complex are the main vectors of onchocerciasis in East and Central Africa and include *S. neavei s.*, *S. woodi*, *S. nyasalandicum*, *S. hightoni*, *S. goinyi* and *S. ovazzae*. These flies breed mainly in rivers and streams in highland areas of East and Central Africa and live in obligate phoresy with freshwater crabs of the genus *Potamonautes*, prawns of the families *Atyidae* and *Palaemonidae* and nymphs of mayflies (Crosskey, 1990; Akinboye et al., 2010). In Central and South America, the main vector is *Simulium ochraceum*. Others include *S. simplicicolor*, *S. met allicum*, *S. callidum*, *S. sanguineum* and *S. guianense* (Lacey and Charlwood, 1980; Shelley, 2002).

More than 99 percent of cases occur in 27 countries in sub-Saharan Africa. Overall, 120 million people live at risk of infection in endemic countries in Africa. Smaller foci of infection have been found in some parts of Yemen, Central and Southern America (Shelley, 2002). Most of the victims are found within the savannah ecotypes. This is particularly evident in the northern part of Nigeria, being in the savannah region. (Etyaale, 2000, Murdoch et al., 2002). The dehumanizing blindness which the disease brings is as worrisome as its socio-economic frustrations (Wogu and Okaka, 2008). In Nigeria, onchocerciasis is widespread and a cause of blindness in most rural

communities. Of all the countries of the world, Nigeria has the greatest number of persons with onchocerciasis (Edungbola, 1991, WHO, 2009; Evans *et al*, 2011; Okanlawon and Osanyintolu, 2012). Visual impairment due to onchocercal eye disease can be demonstrated in about 30% of children aged 5 years who live in hyper-endemic communities in Nigeria; 35% of males and 27% of females in such communities are visually impaired at the age of 30 years (Gemade and Utsalo, 1990; Gemade *et al.*, 1998; Uttah, 2009). The number of Nigerians living in high-risk areas and who therefore require urgent treatment was high (Gemade *et al.*, 1998; Okanlawon and Osanyintolu, 2012). Blindness and impaired vision are the most dangerous disabilities associated with the disease and are seen more among endemic communities living around the foci of transmission. Onchocercal blindness is more common in the savanna bio-climatic zone than in the rain forest zone with sclerosing keratitis standing out as the ocular lesion with the highest prevalence. Males are more affected than their female counterparts, with sex differentials observed to be most marked in the savanna (Nwoke and Ikonke, 1993).

In Africa, the disease has been described as a disease of the future because as the development of the hinterlands proceed, particularly as dams and water projects increase, it will cease to be a disease affecting only small, isolated, poverty stricken and primitive communities in the bush and will become more and more a threat to sophisticated development personnel and other such workers (Duke, 1972, Basáñez *et al*, 2006). As a result of the alarm raised by Burden in the 50's on impending onchocerciasis health problem in the Northern Nigeria, series of entomological researches have come up, attempting to unveil the secret of the blindness, linked with the cases of onchocerciasis in the northern Nigeria. The research also attracted the renowned entomologist Crosskey, working at the Gama valley between 1992/93. There and then, investigation into the bionomics and parasitological of the vector was carried out, producing helpful results about the prevalence of onchocerciasis in that part of northern Nigeria (Crosskey 1954; Murdoch *et al*, 2002, Rimmel, 2004).

Researchers have however revealed that the worst cases of river blindness can be found at the southern part of Adamawa zone around the Katsina-Ala river basin, down to Kogin Baba, near the Taraba river, where settlements were found to have been totally deserted, due to the unbearable outbreak of river blindness in the area (Akogun and Akoh, 1991).

By the time worries about what could be attributed to the uniqueness of river blindness found in northern Nigeria was heightened and the outbreak

became almost uncontrollable, another entomologist known as Collins came up with an interesting finding that there are varieties of the onchocerca vector apart from the *S. damnosum*. He mentioned the *S. onchraceum*, *S. mettalicum* and *S. callicum*, all of which were said to exist in central America and Guatemala (WHO, 1991). The serious debate that ensued as a result of the Collins assertion provoked a lot of investigation, which later exhumed the fact that even in 1926 Blacklock had earlier posited that apart from *S. damnosum*, some other species of the vector known as *S. neavei* also exist in Africa. Whereas in Nigeria, scientist believed that *S. damnosum* alone existed.

However, by 1975 some cytotoxic study about the specific status of cytospecies, to identify the members of the morpho-species of *S. damnosum*; using the cytotoxic criteria in the larvae salivary gland chromosomes was done (Crosskey 1981). After that study, eight other species of *S. damnosum* vector were reported to have been found including:

S. sirbanum found in the Guinea Savannah region of Abuja and Kainji

S. sqwamosumenderlein

S. sudanese

S. bovis de meilon

All of which have the same habitat nature as *S. damnosum* and were noted to be most prevalent in the savannah areas. The confusion however, is that some of these other species of the vector may even be found around Oyo State because Oyo State also falls partly into the guinea savannah, yet no such blindness is found there. Could this suggest that apart from the difference in the vector species found in the savannah region, there may be some other factors enhancing the occurrence of river blindness in the north? Results of certain experiments have suggested that there are pathological and antigenic differences in the races of people found in the north, compared to those in the southern Nigeria (Lewis and Duke 1966). Parasites carried by these other species of the vector may also have specially adapted to the pathological differences or even the antigenic structural differences, thus producing the river blindness in the northern Nigeria. What exactly could be the causal factor of the differences is what the study determines to find out.

2. Methodology

A series of connected methods were adopted. The observatory method was used to study the arthropod vector at its habitat, where we caught the flies alive for laboratory experiments. At the laboratories, series of dissections were done scientifically to find out the type of parasite existing in the different arthropods caught. Our aim here was to determine whether the flies caught and taken to the

laboratories, are actual the *S. damnosum* or that other species were also included and if so, we intend to find out whether the parasite found in each species are the same or of different types. All the results of the dissectional and blood sampling experiments were statically recorded, analysed and carefully evaluated to produce a tenable conclusion.

2.1 Equipment of Research

Apart from Binoculars, which were taken to the study sites to closely study the vectors eggs, larvae, pupa and the hatched arthropod itself; some other research equipments used included a self designed "Cool Box". The "Cool Box" was made of wood exteriorly, while the inside is packed with a white cork insulator. Holes were created on the insulator, big enough to accommodate some feed bottles, inside which the flies were kept after being caught. Inside these bottles were placed cotton wools already soaked with preservative chemicals to keep the flies alive before the laboratory experiments. The entire box when viewed from outside is equipped with a thermometer visible from outside; the thermometer is fixed to take the interior temperature of the box, readable from outside. Because the interior temperature is expected to remain conducive for the flies to survive, the "cool box" is packed with some ice blocks to keep it cool all the time at 14°C or ambient temperature of about 26°C-32°C. there are also two aluminium insect trays, designed for feeding the flies with artificial diets before experimenting on them. Even the insect trays were also designed with thermometer, readable from outside with other equipments like the hydrometer, to read the atmosphere humidity.

2.2 Procedure

Since this study is to determine the reason(s) why river blindness is only found in the northern part of Nigeria, flies (vector) were randomly caught and selected in Oyo state and Kaduna State and scientifically examined for their morphological differences, also to determine whether there are different type of parasites in the flies caught in the north and the south.

Apart from the flies caught, blood samples were taken from adult onchocerciasis patients at the University College Hospital (UCH) Ibadan and Ahmadu Bello University Teaching Hospital in Zaria. These blood samples from victims were examined to find out if there are different onchocercal (parasite) found in the victims.

It must be noted that most of the blood samples taken from people in Kaduna and the adjoining villages were from people already suffering from river blindness.

Skin snips were also collected from these victims to determine the species of the parasites responsible

for such onchocerca skin infections. Our aim is also to discover if there are different species of the parasites responsible for such onchocerca skin infections. Our aim is also to discover if there are different species of the parasite in the northern victims compared with those in the south.

After dissecting the flies, the number of onchocerca parasites in the heads, thorax or the abdomen of each vector (fly) were counted, their stages of development and species were recorded. Measurements of these parasites taken with a micrometer were also recorded. The description of Nelson and Pester (1982) and Duke (1967) helped us greatly to identify the parasites by the time the flies were dissected. The parasites were then counted after staining the preparations with haematoxylin and the final figures were recorded as acceptable. The blood samples and the skin snips were equally tested for the parasites and these were also counted and recorded accordingly.

3. Results

Table 1 shows the summary of results got from laboratory experiments on the blood samples taken from respondents in the two states. Note that in every 200 infected people tested, some have not shown any sign of the parasite. It was found that those without the parasites have series of nodules on their bodies. We also found that there were some slight differences in the species of the vector caught in the northern Nigeria. This finding was made when trying to measure the insects we caught to know the differences in the sizes of the vectors caught in two different regions.

Experts have dropped some hints on how to identify the difference in these flies. The parameters include examination of the vector under a transmitted light to observe whether the flies are clear, opaque or semi-opaque; examine the size of the abdomen, the presence or absence of corpus luteum or fat or slender abdomen (Lewis and Duke, 1966). All these parameters were followed in studying the flies.

Table 1: Blood sample analysis in Oyo and Kaduna states

State	No of people examined	No of people with Parasite	%	Type of Parasite
Oyo	200	159	79.5	<i>O. volvulus</i>
Kaduna	200	189	94.5	<i>O. volvulus</i>

Tables 2 and 3 further show our findings from the dissection experiments. Intentionally, the same number of the flies was caught in each state and the same number of these flies was randomly selected for the experiments. It was discovered that the population of the flies in Kaduna within the same period was alarmingly great, such that it was very easy to capture the flies; much easier than the case in our study site in

Oyo state. This prevalence in Kaduna actually produced the bite per person per hour that is greater than what we found in Oyo State. You will also notice from this table that the infective and the infected vector are much more of the nematodes (parasites) were found on the heads of the vector (flies) upon dissection. This finding indicates that there would be more parasites in the victim's blood stream at a given time in Kaduna than in Oyo State, a situation that may compound health problems in Kaduna (North) than in Oyo (South).

Added to the discovery that a type of the vector, which was slightly different from the *S. damnosum* that is generally found in Oyo state, dissectional experiment was specially carried out to find out if the parasite it carries is different from the one found on normal *S. damnosum* flies.

4. Discussion

This work has been able to identify some causal analysis of onchocerciasis between the two ecological zones studied. The result from table 1 might agree with experts' assertion that the formation of nodules is the result of antibodies fighting with the onchocerca parasite and that the nodules are just the residue of the destroyed parasites and its effective enzymes. Increased number of nodules in the body might be an increased amount of immunity in the victim (Israel 1959; Browne 1961; WHO, 1995). We discovered that a type of this insects have longer abdomen and longer thoracic regions, this agrees with Crosskey (1981) and Bassey (1998) that another species of the vector exists in the guinea savannah and other savannah regions which he called "*S. boris de meillon*". This other species looks lighter in colour, while the *S. damnosum* appears darker. The *S. damnosum* is characteristically stout with short antennae of about ten equal stumpy segments but this other species found in Kaduna is a little slender with longer thorax segment, as against the humped thorn of *S. damnosum*, male or female. In line with Duke *et al* (1966) and Manafa and Isama (2002) some differences were found in the pathogenicity and the antigenic structure of the *O. volvulus* found on the new vector found in Kaduna, which indicated that we could be dealing with a variant of the *O. volvulus* parasite, which might have adapted to and mingled the local population of the *Simulium* in the villages. This situation might point to the reason why there are differences in the disease patterns in the northern and the southern Nigeria. Duke (1966) stated that the different patterns of diseases in the savannah area of the northern Nigeria can be attributed to (1) greater longevity of the vector population in that savannah region than in other regions. (2) Similarly, difference in this ocular onchocerciasis has been attributed to the different type

of *O. volvulus*, that may have adapted to the local population of the arthropod vector. Therefore the cause of river blindness might be due to the presence of some other type of the vector whose parasitic nematode have adapted to the climatic and other survival needs as suitable to the *Simulium damnosum*.

This adapted type of vector may not be easily identifiable, though their effects on the victims will produce something different from what the known *S. damnosum* would produce e.g. river blindness. This type of adapted vector was found in our Kaduna study area.

While comparing the pattern of the onchocerciasis in the rainforest and that of the savannah regions, Anderson *et al* (1974), said that the different clinical manifestations could be due (3) to the duration of the transmission, the pathogenicity and behaviour of the different types of parasites. Anderson also, postulated that (4) different races react differently to parasites as hosts. He explained that the genetic differences in the Yoruba, Fulani, Hausa, Tiv as races, may react differently to onchocerca parasites, such that the same parasite might produce different windows for different manifestations of diseases.

Furthermore, the nutritional pattern of each race is different and such can produce a different pattern of immunity from one race to the other. What is more is the fact that (5) the location of each race is different, hence the geographical pattern and situations might present some concomitant infections through certain organisms, which could offer an extended reaction to the onchocerca parasites, to produce the different disease patterns as found in the northern and southern Nigeria (Anderson *et al* 1974).

Finally, according to Anderson (1972), experiments have shown that microfilaria of the vector if it goes into the eye can be greatly corneotropic (Duke and Anderson 1972), particularly in the savannah regions. Corneotropism indicates danger or a negative effect to the cornea of the eye, which can impair sight. It affects the level at which the eye can accommodate light (tropism).

All these findings added to expert explanations may have analysed the reason(s) why river blindness have specifically become an occurrence only in the northern part of Nigeria.

4.1 Recommendation

The findings here have not exhausted what we need to know about the causes of river blindness in the northern part of Nigeria as against the south, where the same vector seem to exist.

Our government need to sponsor more research into this aspect in order to find ways of stopping the nuisance and the dehumanizing health problem caused by arthropod vector i.e. river blindness.

Table 2: Results of analysis of flies in Oyo state

	No of flies caught	No of flies dissected	Infected flies		Infected flies		Mean F.M.H	Bite/person per day rMH x 10	Infective bite/person/day	Ratio of infective divided by infected bites
	A	B	% C	% D	No E	% F	G	H	F x H	
July	352	179	5	2.79	4	2.23	4.55	45.5	1.01	0.8
August	14	14	0	0	0	0	0.48	4.8	0	0
September	25	25	0	0	0	0	0.46	4.6	0	0
October	41	36	1	2.78	0	0	0.91	9.1	0	0
November	0	-	0	0	0	0	0	0	0	0
December	0	-	0	0	0	0	0	0	0	0
January	0	-	0	0	0	0	0	0	0	0
February	0	-	0	0	0	0	0	0	0	0
March	70	28	0	0	0	0	1.65	16.5	0	0
April	160	115	0	0	0	0	3.07	30.7	0	0
May	1038	193	2	1.04	1	0.52	23.66	236.6	1.23	0.5
June	989	264	2	0.76	1	0.38	16.76	167.6	0.64	0.5
Total/mean	2689	854	10	1.17	6	0.70	6.44	64.43	0.45	0.6

Table 3: Result of analysis of flies in Kaduna state

	No of flies caught	No of flies dissected	Infected flies		Infected flies		Mean F.M.H	Bite/person per day rMH x 10	Infective bite/Person/day	Ratio of infective divided by infected bites
	A	B	% C	% D	No E	% F	G	H	F x H	
July	352	179	85	47.5	80	45.0	8.55	85.5	6	0.94
August	14	14	5	35.7	3	21.4	2.80	28.0	3	0.60
September	25	25	14	56.0	8	32.0	1.50	15.0	2	0.57
October	41	36	23	63.8	15	42.0	2.30	23.0	2	0.65
November	0	-	0	0	0	0	0	0	0	0
December	0	-	0	0	0	0	0	0	0	0
January	0	-	0	0	0	0	0	0	0	0
February	0	-	0	0	0	0	0	0	0	0
March	70	28	16	54.1	12	43	1.65	16.5	0	0.75
April	160	115	94	81.7	80	69.6	2.70	27.0	-	0.85
May	1038	193	132	68.4	100	52	44.35	443.5	-	0.76
June	989	264	105	39.8	75	28.4	3.77	37.7	-	0.71
Total/mean	2689	854	474	55.5	373	43.7	67.62	676.2	13	0.79

References:

- Akinboye, D.O., Okwong, E., Ajiteru, N; Fawole, O., Agbolade, O.M., Ayinde, O.O., Amosu, A.M., Atuloma, N.O.S., Odula, O., Owodunni, B.M., Rebecca S.N and Falade, M.(2010): Onchocerciasis among inhabitants of Ibarapa Local Government community of Oyo State, Nigeria. Biomed. Res. 21 (2): 174-178.
- Anderson J., Fuglsand H., Hamilton P.J. and Marshall T.F. (1974). Studies on onchocerciasis in the United Cameroon Republic 11. Comparison of onchocerciasis in rain forest and sudan savannah. Trans. R. Soc. Trop. Med. Hyg., 68 (3): 209 – 222.
- Basáñez M G, Pion S D *et al* (2006) River blindness: a success story under threat? PLoS Med 3:e371.
- Bassey, S. A. (1998). *Cytological studies and distribution of Simuliumdamnosum complex in Nigeria, Cameroon and Equatorial Guinea*. Ph.D thesis, Ahmadu Bello University, Zaria, Nigeria.
- Boakye, D. A. (1993). A pictorial guide to the chromosomal identification of members of the *Simuliumdamnosum*Theobald complex in West Africa with particular reference to the Onchocerciasis Control Programme Area. *Tropical Medicine and Parasitology* 4: 223-244.
- Crosskey R W (1954) Onchocerciasis in the Galma valley area, northern Nigeria. W. Afr. Med. J. (n.s.) 3: 75 - 79.
- Crosskey R W (1981). A review of *Simuliumdamnosum* S.I. and Human onchocerciasis in Nigeria with special reference to geographical distribution and the development of a Nigerian National control campaign. *Tropenmedizin und Parasitologie* 32: 2 – 16.
- Crosskey R. W. (1990). The Natural History of Blackflies. John Wiley and Sons Limited, England. 711 pp.
- Duke B O L (1966). Onchocerca-Simulium complexes. The survival of *Simuliumdamnosum* after high intakes of Microfilariae of incompatible strains of *Onchocerca volvulus* and the survival of the parasites in the fly. *Annals of Tropical medicine and Parasitology* 60: 495-500.
- Duke B.O.L (1967). Infective filaria larvae, other than *Onchocerca volvulus* in *Simuliumdamnosum*, Ann. Trop. Med. Parasitol. 61: 200.
- Duke, B O L (1972). Onchocerciasis. *British Medical Bulletin*. 28: 66-71.

12. Duke B.O.L., Lewis, D.J. and Moore, P.J. (1966). Onchocerca-Simulium complexes. I. Transmission of forest and Sudan-savannah strains of Onchocerca volvulus from Cameroun by Simuliumdamnosum from various West African bioclimatic zones. *Annals of Tropical Medicine and Parasitology*, 60, 318-336.
13. Duke B O L and Anderson J (1972). A comparison of the lesions produced in the cornea of rabbit eye by microfilariae of the forest and Sudan-Savannah strains of Onchocerca volvulus from Cameroons. *The Clinical picture. J. Trop. Med. Parasit.* 23: 354-368.
14. Edungbola L. D (1991). Onchocerciasis Control in Nigeria. *Parasitology Today*, 7: 97-99.
15. Etya'ale, D.E. (2001). Vision 2020: Update on Onchocerciasis. *J. Comm. Eye Health*, 14: 19-21.
16. Evans, D., McFarland, D., Adamani, W., Eigege, A., Miri, E., Schulz, J., Richards, F. O. (2011). Costeffectiveness of triple drug administration (TDA) with praziquantel, ivermectin and albendazole for the prevention of neglected tropical diseases in Nigeria. *Annals of Tropical Medicine and Parasitology*, 105(8), 537-547.
17. Gemade E I I, Jiya J. Y, Nwoke, B E B, Ogunba E O, Edeghere, H, Akoh, J I and Omojola, A. (1998): Human onchocerciasis: current assessment of the disease burden in Nigeria by rapid epidemiological mapping. *Annals of Tropical Medicine and Parasitology*, 92 Supplement No. 1: S79-S83.
18. Gemade E I. and Utsalo S J (1990). Onchocerciasis in Benue State of Nigeria. VIA. The prevalence and distribution of the disease among the human population in Sati-Ikyov village. *Acta Leidensia*, 59: 51-58.
19. Kale O. O. Onchocerciasis (1998): The Burden of Disease. *Annals of Tropical Medicine and Parasitology*; 92(Suppl. 1):S101-15.
20. Keenan, J. D., Hotez, P. J., Amza, A., Stoller, N. E., Gaynor, B. D., Porco, T. C., & Lietman, T. M. (2013). Elimination and eradication of neglected tropical diseases with mass drug administrations: a survey of experts. *PLoS Neglected Tropical Diseases*, 7(12), e2562. doi:10.1371/journal.pntd.0002562
21. Lacey L A and Charlwood J D (1980). On the biting activities of some anthropophilic Amazonian Simuliidae (Diptera). *Bulletin of Entomological Research*. 70(3): 495-507.
22. Lewis, D.J. and Duke B.O.L (1966): Onchocerca-Simulium Complexes. Variation in West African Female Simuliumdamnosum. *Ann. Trop. Med. Parasit.* 60: 337.
23. Mafuyai, H. B., Post, R. J., Vajime, C. G. and Molyneux, D. H. (1996). Cytotaxonomic identifications of the *Simuliumdamnosum* complex (Diptera: Simuliidae) from Nigeria. *Tropical Medicine and International Health* 1: 779-785.
24. Manafa O. U. and Isamah A. N. (2002): Local Knowledge and Attitudes about Onchocerciasis in Oji River Local Government *Journal of Epidemiology and Infection* 129: 629 -633.
25. Mboera, L.E.G. (2010) NIMR at 30: History, Development, Achievements, and Success Stories. National Institute for Medical Research, Dar es Salaam, Tanzania.
26. Murdoch ME, Asuzu MC *et al.* (2002). Onchocerciasis: the clinical and epidemiological burden of skin disease in Africa. *Ann Trop Med Parasitol*; 96:283.
27. Nelson G S and Pester F R N (1982). The Identification of Annals of Tropical Medicine and Parasitology. Infective filarial larvae in Simuliidae. *Bulletin of World Health Organization* 27:473.
28. Nwoke B E B and Ikonke E U (1993). Onchocerciasis blindness: The Nigerian Situation. *Nigerian Journal of Optometry*, 7(1): 2-7.
29. Okanlawon, F. A., & Osanyintolu, G. D. (2011). Pilot training of community mobilizers as health educators to prevent onchocerciasis in Bugai, Kaduna State, Nigeria. *International Quarterly of Community Health Education*, 32(2), 171-176. doi:10.2190/IQ.32.2.
30. Remme JHF (2004): The global burden of onchocerciasis in 1990. World Health Organization, Geneva
http://www.who.int/healthinfo/global_burden_disease/Onchocerciasis%201990.pdf (Accessed on April 25, 2011).
31. Shelley, A. J (2002): Human onchocerciasis in Brazil: an overview. *Cad. Saúde Pública*. 18 (5).
32. Uttah, E.C. (2009). Clinical manifestations of mesoendemic onchocerciasis in the Upper Imo River Basin, Southeastern, Nigeria. *Iranian Journal of Parasitology*, 5(2), 33-41.
33. Workneh W, Fletcher M and Olwit G (1993). Onchocerciasis in field workers at Baya Farm, Teppi Coffee Plantation Project, southwestern Ethiopia: prevalence and impact on productivity. *Acta Trop*.54: 89-97.
34. Wogu MD and Okaka CE (2008). Prevalence and socio-economic effects of onchocerciasis in Okpuje, Owan West Local Govt. Area, Edo State, Nigeria. *Int. J. Biomed. Hea. Sci.*, 4(3): 111-119.
35. World Health Organisation (1991). Report of the meeting for ivermectin distribution through the primary Health care systems. *WHO/PSL/91.24*.
36. WHO (2009), Community Directed Interventions for Priority Health Problems in Africa: Results of a Multi-Country Study: *Bulletin of World Health Organisation*: 509-518.
37. World Health Organization. (2011): Prevention of blindness and visual impairment: priority eye diseases. <http://www.who.int/blindness/causes/priority/en/index3.html> (Accessed on October 10, 2011).