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Bionomics of Cyclops in Communal Waters and their Guinea Worm Infection Status in Ebonyi State, Nigeria Fifteen Years After It Was Declared Guinea Worm Free

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ABSTRACT: *Nigeria reported highest incidence of dracunculiasis in the world in 1991 (WHO 1991). Ebonyi, a small state in the south-eastern part of the country was rated the most endemic with a total of 3,370 cases reported in 1996 alone (Global 2000 & Ojodu 2001). In 2005, the World Health Organisation proclaimed that the disease was eradicated from Ebonyi state and indeed, Nigeria, and the country was declared guinea worm free. This study examined the bionomics of Cyclops in sampled fresh waters in the state and their guinea worm infection status fifteen years after it was declared Guinea worm free by the World Health Organisation.. The study was done in three phases. Phase one was between 2004 and 2005 (before the proclamation), phase two was between 2005 and 2006 (shortly after the proclamation), and phase three was in May/June 2020 (fifteen years after the proclamation). Out of 5,529 Cyclops examined during the first phase using microscope, 36 were found infected with dracunculus larvae. Prevalence by seasonal variation showed that more Cyclops occur during the months of dry season (November to April) with peak transmission occurring between February and April. Out of 1,443 Cyclops studied in the second phase, none was found infected with Dracunculus larvae, indicating that guinea worm was actually eradicated in the state. Repeated study in the third phase in 2015 authenticated that finding as none of the Cyclops was found infected with guinea worm larvae. This implies that there is no more prevalence of infective guinea worm larvae in the communal water sources in the area. But the abundance of Cyclops were more in the communal water sources in the third phase due to suspension of regular treatment of ponds with abate which controls Cyclops population in water bodies. The increase of Cyclops population in the water bodies calls for serious attention by responsible authorities and collaborating agencies with the view to ensuring more effective surveillance system as any introduction of one case of dracunculus larvae into the water bodies will result in explosive outbreak of the disease in a larger scale in the area.*

KEY WORDS: communication, bionomics of cyclops, communal waters, guinea worm infection, Ebonyi State-Nigeria

INTRODUCTION

Dracunculiasis, also known as Guinea Worm Disease (GWD) is a debilitating tropical disease caused by the growth of Dracunculus parasite in the subcutaneous tissue of mammals. The parasite enters a host by way of drinking of stagnant water contaminated with copepods (water lice) infested with guinea worm larvae. More or less one year later, the disease appears with a painful, burning sensation as the female worm forms a swelling and an eruption, usually on the lower limb.

The earliest record of the disease was found in an Egyptian medical text dating from the 15th century B.C. and was first called "Guinea Worm" disease by an European from Switzerland who found it among Africans living along coast of Guinea in 1611 A.D. (Oguoma,1997). The disease has been reported to have affected large populations in the Sub Saharan Africa, leading to low agricultural productivity, disability, incapacitations and absenteeism of civil servant and pupils from work and schools respectively (Belcher., 1975). The distribution of Dracunculiasis is highly dependent on the nature of domestic water supply (Belcher, 1975). Dracunculiasis is known to be endemic in many parts of the tropics and subtropics especially in many poor rural areas where communities have no access to portable water. The disease is widely reported in Nigeria with known endemic states like Ogun, Ondo, Edo, Delta, Lagos, Kwara, Sokoto, Borno, Niger, Bauchi, Katsina, Benue, Abia, Enugu, Anambra, Imo and Ebonyi which was rated the most endemic state in the country with a total of 3,370 cases reported in 1996 (Global 2000).

Dracunculiasis is transmitted by different species of Cyclops, a water flea that has been infected by the 3rd stage larvae of *D. medinensis* (Nwosu, Ifezulike and Anya, (1982). Some of the species of the Cyclops identified in Nigeria by Muller (1970) to be naturally infected with *D. medinensis* include *Mesocyclops leukarti*, *M. leukarti aequatorialis*, *M. hyalinus* and *Themocyclops nigerianus.*

The Programme for eradication of Dracunculiasis started in Ebonyi State in 1997 with a case search carried out by Nigeria Guinea Worm Eradication programme (NIGEP) and reported 3, 370 cases. The intervention activities put in place to eradicate the disease included control of the Cyclops intermediate host, filter distribution, water provision and treatment and health education. Many studies have also been carried out on Dracunculiasis in some parts of the country. Such studies include those of Nwoke, (1992) in Imo State; Nwaorgu, (1991) in Enugu State; Ogwumba and Kale (1985) in Ogun and Oyo States; Oguoma, (1997) and Njoku (1995) in Plateau State. Despite these intervention programmes, information on bionomics of Cyclops in intermediate hosts of Dracunculiasis has not been fully studied in rural areas of Ebonyi, one of the states in Nigeria with the highest rate of illiteracy, poverty and diseases.

Objectives of Study

The broad objective of the study was to ascertain and communicate the bionomics of Cyclops in communal water sources and their guinea worm infection status in Ebonyi state, Nigeria ten years after the World Health Organisation proclaimed the country guinea worm-free. Specifically, the study was meant to:

i. Identify the species of Cyclops in communal water sources of Ebonyi state, Nigeria (if any),
ii. Ascertain the temporal and spatial abundance and distribution of the Cyclops,
iii. Determine the species diversity indices of Cyclops in fresh waters in Ebonyi (if any),
iv. Determine the prevalence of guinea worm in communities whose communal water ponds were infested with guinea worm-infected Cyclops.
v. Ascertain and communicate the present guinea worm-infection status of Cyclops in communal water sources after the proclaimed eradication of guinea worm in Ebonyi State.

Research Questions

1. What species of Cyclops are in communal water sources of Ebonyi state, Nigeria (if any)?
2. What is the temporal and spatial abundance and distribution of the Cyclops?
3. What is the species diversity indices of Cyclops in fresh waters in Ebonyi (if any)?,
4. What is the prevalence of guinea worm in communities whose communal water ponds were infested with guinea worm-infected Cyclops?
5. What is the present guinea worm-infection status of Cyclops in communal water sources in Ebonyi state, Nigeria?

REVIEW OF LITERATURE

Dracunculiais is known to be endemic wherever guinea worm and the Cyclops intermediate hosts are distributed, especially in many parts of the tropics and subtropics; more so in the poor rural areas of India, Middle East, Asia and Africa where communities have no or little access to portable water (Belcher, Wurapa, Ward, Lourie 1975). It was estimated that 48.3 million cases of dracunuliasis occur annually throughout the world, about 30 million in Asia, 15 million in Africa and 3.3 million in other parts of the world (Stoll, 1947). The World Health Organization (WHO) (1989) estimates the infection rate of the disease in 20 sub-Sahara African countries at 10 million with 140 million people at risk. The prevalence of the disease has been reported in West Africa ((Lyons, 1972). The disease was endemic in Chad, Cameroon, Nigeria, Togo, Ivory Coast, Burkina Faso, Ghana, Mali, Liberia, Senegal and Mauritania (Muller 1971). The peak transmission for Burkina Faso is August to November and it was the fourth highest endemic country after Sudan, Nigeria and Ghana (Steib and Mayer 1988).

Studies also indicate that Cyclops is mainly distributed in ponds and wells in endemic foci of the disease where availability of food and some immunological conditions affect their growth, reproduction and infectivity (Kale 1977). Cyclopoid copepods can be broadly divided into carnivorous and herbivorous species, the former living on the microcustaceans, annelids, rotifer, insect larvae, protozoa and aquatic nematodes; the later in algae and diatoms (Kale 1977).

Guinea worm, Cyclops, and Dracunculiasis in Nigeria

In Nigeria, active dracunculiasis transmission occurs virtually in every state although the level of endemicity varies. The disease has been named locally in Nigeria in the three major dialects, "Kunukunu" in Hausa, "Sobiya" in Yoruba and "Nwori" in Igbo and "Akwara" or "Ehu" in Abakaliki, the local of Ebonyi state. Nigeria reported highest incidence of dracunculiasis in the world in 1991 (WHO 1991). First case search established that 5,879 endemic villages existed in Nigeria. 653,620 cases were reported for the epidemiological year 1987/88; 653, 470 in 1988/89; 394, 784 in 1989/90; and 270, 804 in 1990/91 (Ojodu 2001). That First Case Search also established that only 16 out of the 36 states in Nigeria recorded no case of dracunculiasis. Nineteen states and 21 local government areas reported at least one or more cases (Ojodu 2001). According to that report, seven states - Ebonyi, Enugu, Zamfara, Sokoto, Borno and Oyo accounted for 6,571 cases (83%) of all cases.

In the South Eastern part of Nigeria, dracunculiasis was transmitted throughout the year but the peak transmission period was September to May with the highest peak being January to March (Maduka 2000). Maduka (2000) reported that the number of cases of dracunculiasis in the South East zone reduced from 313,047 cases in 1989 to 4,646 in 2000. The result of the case search of 1987 and 1988/89 showed that all the states in the Eastern zone of the country except Akwa Ibom State were endemic of dracunculiasis (Ojodu 2001). Sex distribution of dracunculiasis in the zone showed that males (57% were infected more than than 43% female (Maduka, 2000). Among the LGAs existing in the zone, Ezza North LGA in Ebonyi had the highest prevalence of the disease with a total of 161 cases, followed by Aninri LGA in Enugu State with 70 cases. Three other endemic LGAs in the zone are Ohaukwu LGA in Ebonyi State (53) cases, Abakaliki in Ebonyi State (37) cases and Ikwo LGA in Ebonyi State (32) cases (Maduka 2000).

Ebonyi State which was the most endemic state for dracunculaliasis is in the South Eastern Zone of Nigeria was created in 1996. On creation of the state, Abia State handed over her endemic LGAs (Afikpo North, Afikpo South, Ohaozara, Ivo and Onicha) to Ebonyi State and Enugu State also relinquished 8 out of her 11 endemic LGAs (Abakaliki, Ezza North, Izzi Ezza South, Ohaukwu, Ikwo, Ishielu and Ebonyi) to Ebonyi State, hence the state assumed the most endemic in the country with a total of 3,370 cases reported that same year 1996 (Maduka 2002).

Transmission of guinea worm (*Dracunculus medinensis*) to humans

Within any endemic situation, where there is a human reservoir of dracunculus, it is the intensity of contact with the copepods intermediate host (Cyclops) that determines levels of disease transmission. Water quality is the key to copepod density. Pipe borne water is copepods free and thereby completely safe from dracunculiasis. Draw wells have a few crustaceans (20 per 2 liters) but none is infective because "rope and bucket" access to water prevents leg immersion by *Dracucunliasis* carriers (Nwosu *et al*., 1982).

Within a pond, infected Cyclops tends to concentrate in the shallows, presumably because they require more oxygen. It has also been noted that Cyclops carrying third stage infected larvae, tend to sink deeper towards the bottom of a pond. From the disease transmission point of view, lower water levels in ponds at the end of the dry season, maximize copepod densities giving a peak in copepods ingestion by humans. Women, wading through the shallows to scoop up drinking water, will harvest greater yields of the disease carrying crustaceans. When ponds ultimately dry out, people are forced into long walks to carry water from holes excavate in dry river bed holes can also breed water fleas and disease.

When the larvae come in contact with the water it act as food for predatory Cyclops, man ingest the infected Cyclops in water and so the cycle continues. Low level of water in ponds during the dry season maximizes Cyclops densities giving peak ingestion by man. Moorthy (1938) noted that larvae which are released into the water remain infective to Cyclops for only about 4 days.

Study Design

In the 1st Stage of this study (carried out in between 2004-2005), water from sixty (60) communal ponds in the corresponding 60 selected communities were examined for Cyclops, and subsequently the guinea worm infection status of the Cyclops was determined. In the 2nd Stage of the study (carried out between 2005 and 2006), an average of 360 individuals from each of the communities whose communal ponds were infested with guinea worm infected Cyclops were examined to determine the community-prevalence of guinea worm infection. The third stage was carried out in May\June 2015 to evaluate the current guinea worm infection status of Cyclops in the study area.

Sampling of water ponds

The water sources were sampled for Cyclops monthly from April 2004 to March, 2005. The water samples were collected using a wide mouthed of 5 litres capacity cylindrical vessel from communal water sources\ponds (Onwuliri *et al.,* 1991). The container was lowered into each water source, at different points in random manner and filled to a graduated level using a deep handle (Njoku, 1995). This method was not only found to be effective but agreed with the method used in collecting water by villagers. Before each sampling, the water body was allowed to settle undisturbed to ensure natural distribution of the Cyclops, if present.

Collection of Cyclops

In this method, two strainers were used - a large pore tea strainer and a smaller pore plankton net. The tea strainer was used to strain off large materials collected with the Cyclops. The water sample was then centrifuged at 100 rpm for 5 minutes to settle out other dead materials collected along with the Cyclops and which pass through the tea strainer. The supernatant and measured samples with the Cyclops were then filtered through a sieve of 100 – mesh to an inch. This retained the entire Cyclops on the sieve. The Cyclops on the sieve was then washed into a Petri dish by inverting the sieve over the dish and pouring distilled water on it and were counted under the microscope.

Preservation of Cyclops

Because counting the Cyclops alive is difficult, the Cyclops was fixed with 5% formalin before the counting was done. By filtering 10 liters of the pond water through monofilament nylon filter, the residue was collected in duplicate from each of the 60 ponds sampled. Each of the sample bottles contained 5% formalin. The preserved Cyclops was filtered and concentrated in 1ml of normal saline. Each drop of the concentrate was then observed and the number of Cyclops recorded and density per litre of the pond worked out and was expressed as the total number of Cyclops per a liter of water.

Identification of guinea worm-infected Cyclops

This was estimated by straining 10 litres of water collected through the monofilament nylon filter. The Cyclops was sedimented with a few drops of normal saline and transferred to Petri dishes. Infected Cyclops were detected by placing the Petri dishes in a refrigerator for 10 hours after which they were removed and allowed to stand at room temperature (28^{o}c) for 15 minutes. This inactivated the Cyclops and observation of *D. medinensis* larvae was carried out under the microscope. 0.05ml of HCL was added to enhance the observation as this destroyed the exoskeleton of the Cyclops and activated the larvae in the infected ones. The infected Cyclops were easily seen by the active movement of the larvae of *D. medinensis* in the Cyclops under a state of coma. Infection of the Cyclops was based on mature Cyclops only.

Study of human population

This was the 2nd Stage of the study, carried out for a period of 12 months (April 2005 – March 2006), to determine guinea worm infection status of individuals sampled in communities were guinea worm infected Cyclops were encountered during the 1st Stage of the study. Nineteen such communities were identified from the six LGA earlier chosen for Cyclops study. During the period of the study, a total of 6980 (average of 367 subjects from each of the 19 selected communities) were examined for signs and symptoms of guinea worm infection.

Pre-survey contacts and mobilization were carried out before the actual data collection so as to be sure of the people’s consent and cooperation. The village heads helped to suggest the order of visit to each village or the household to be examined in sequence. Basic information relating to the level of endemicity of dracunculiasis in the area was collected during the preliminary tour. The actual data collection was carried out through house-to-house visits. These involved data collections by visual examination and oral interviews of subjects. At each visit, the entire members of the household were examined in order of seniority. Records were taken of the number of cases seen. Through house to house survey cases that could not have come out if it were to be done at the village square were observed. Diagnosis was by direct examination and observation of protruding *D. medinensis* from the body. Treatment of some of the guinea worm infected individuals was carried out by NIGEP Field Officers who were working for the eradication of the disease.

Sampling of communal water bodies

Water bodies in six communities chosen randomly from each of the LGA previously studied were sampled for Cyclops. The water bodies that contained guinea worm infected Cyclops were among those sampled from each of the six LGAs.

Data analysis

Descriptive statistics and Microsoft Excel Software Package which displays significant differences among variables at 0.05 (5%) level of significance was used for data analysis. Ecological statistical procedures were also employed for the determination of Species diversity indices or Ecological indices for the Cyclops species. Diversity indices used to characterize species abundance are Margalef’s species richness, Shannon’s index or Shannon-Wiener diversity index, Evenness index, and Simpson’s dominance index (Ogbeibu, 2005). These indices are based on the relationship of the total number of species ‘*S*’ in a community and the total number of individuals (*N*) observed (Krebs, 1972). Margalef’s species richness

(*d*) is expressed as $d = \frac{S-1}{In\ (N)}$, where '*S*' is the total number of species encountered, (*N*) is the total number of individuals, and '*In*' is the natural or Naperian logarithm or $\log_e$ (Margalef, 1958). Evenness shows how the species abundance is distributed among the species in a community. Shannon-Wiener Index of Diversity (*H*) combines species richness and evenness into a single value expressed as $H = \frac{N \log N - \sum fi \log fi}{N}$, where *fi* is the abundance and *N* the total number of individuals in the species (Fisher *et al*., 1943). Evenness index (*E*) can be defined as the ratio of the observed diversity (*H*) to the maximum diversity ($H_{max} = \log_2 S$) which is expressed as $E = \frac{H}{\mathrm{H}max}$ or $\frac{H}{\mathrm{logS}}$.
A greater number of species, as well as a more even distribution among species will therefore increase species diversity measured by Shannon-Wiener Index (Lloyd and Ghelardi, 1964). However, Simpson's Dominance Index (*C*), which is the probability of picking two organisms at random that are different species, is expressed as $C = \sum(Pi)^2$ or $C = \sum(\frac{ni}{N})^2$, where *ni* is the number of individuals of the *ith* species, *N* is the total number of individuals for all species, *Pi* is tahe proportion of individuals of species *i* in the community (i.e., $Pi = \frac{ni}{N}$). Since the formula $\sum(\frac{ni}{N})^2$ refers to a finite population, an unbiased estimator known as Simpson's Index (*D*), expressed as $D = \sum\frac{ni(ni-1)}{N(N-1)}$ was developed for sampling from infinite natural population and this index (Simpson's dominance index) is weighted towards the abundance of the commonest species (Fisher *et al*., 1943). Hence, the following formulae were used to determine the species diversity indices of Cyclops encountered during the 1st and 3rd Stages of the study.

Margalef's Index or Species Richness, $d = \frac{S-1}{\mathrm{In}\ (N)}$;

Evenness index, $E = \frac{H}{\mathrm{H}max}$ or $\frac{H}{\mathrm{logS}}$;

Shannon-Wiener Index of Diversity (*H*) = $\frac{N \log N - \sum fi \log fi}{N}$;

Simpson's Dominance Index, $C = \sum(Pi)^2$ or $C = \sum(\frac{ni}{N})^2$;

Simpson's Index, $D = \sum\frac{ni(ni-1)}{N(N-1)}$

DISCUSSION

The reduction of cases of guinea worm infection led to the proclamation of Ebonyi alongside with other states in Nigeria free of guinea worm disease. This was an indication that the impact of the intervention activities instituted by NIGEP and the supporting Agencies towards guinea worm eradication in the state was working. This agrees with the 2005 to 2006 NIGEP statistical report on Guinea worm eradication in Nigeria in which sharp reduction of cases was yearly reported. December, 1995 was set as the target date for global eradication of dracunculiasis by African Health Ministers (WHO, 1991) but the target was not achieved. The Nigeria Guinea Worm Eradication Programme (NIGEP) started its eradication effort in Ebonyi State in

1996/1997 with 3370 reported cases (Maduka 2002). The activities of NIGEP and other collaborating agencies had resulted to an impressive decline in the number of cases reported from 3370 in 1996/97 to 1245 in 2002. While the effort came close to final eradication of the disease, the process dragged on for 14 years until zero annual report case was reach in 2009. Since 2010 surveillance was maintained in all the endemic communities by NIGEP as a process for attaining certification of the country free guinea worm disease by WHO. The first and second stage of the study carried out between 2004 and 2006 confirmed the prevalence of guinea worm effected Cyclops and dracunculiasis in Ebonyi State with prevalence rate of 0.65% and 10.48% respectively. The prevalence is lower than the number previously reported elsewhere in Nigeria (Nwosu, Ifezulike and Anya 1982, The low prevalence rate obtained is impressive because Ebonyi State had been rated the most endemic state in the country.

First Stage Study

Some species of Cyclops were encountered during the first stage of study of abundance, distribution and infectivity of Cyclops (2004 to 2005). Two out of the three species of Cyclops identified *Thermocyclops and Mesocyclops* were implicated as the intermediate host for dracunculiasis Prevalent in the study area. The same species were implicated as the major intermediate host for dracunculiasis in Nigeria (Boxshall and Braide 1991. Our observation showed that only two of the species found – *Thermocyclops oblongatus nigerianus and Mesocyclops acquatorialis* harboured infective larvae of *D. medinesis.* Whenever these species occurred, some population of the area could be infected with larvae of dracunculus. Specie distribution of the cyclops in the study area gave reliable information of the water sources that can habour cyclops infected with *D. medinensis* larvae.

The result of the study showed 0.65% infection rate of Cyclops in the area. The low infection rate is due to massive and integrated cyclops control programme embarked upon by Global 2000 and NIGEP as part of activities for dracunculiasis eradication in the state.

Second Stage Study 2005 to 2006

The result of the second stage study showed prevalence of guinea worm disease among the 19 communities in the six Local Government Areas earlier reported of guinea infected Cyclops in their communal ponds. The report showed that the prevalence was highest in Agu otu Ogboji in Ishielu LGA with 58 cases (14.50%). The high prevalence in the area was due to cultural believe of the community and the entire Ishielu people which prevented treatment of their pond. Their culture forbid people from entering their pond as they believe that treatment of their pond with Abate could led to destruction of their sacred fish which consequently may led to the death of their children. The NIGEP Field Officers working in the area risked their lives in an attempt to influence the treatment of the sacred ponds. This showed that pond treatment with Abate is a major intervention strategy in dracuncunliasis eradication. Similar observations have been made in other endemic areas (Nwosu 1989 and Nwobi et al 1996). In contrast, the other two LGAs (Izzi and Ebonyi) have their ponds treated freely during the peak transmission season hence the low prevalence rates recorded in these LGAs.

The prevalence of dracunculiasis in the area affected both sexes and all age groups. In like manner, both sexes are affected in other endemic states such as Benue State, Kogi State , Nassarawa State, Plateau State and Sokoto State among others (Onwuliri, Braide,Anosike and

Amaguna 1990, Njoku 1995, Fabiyi 1991 and Oguoma 1997). The pattern of the infection may be related to the high exposure or consistent exposure to sources of water infected with cyclops. It was observed that all ages were affected by guinea worm infection in the study area. This showed that factors such as behavioral differences seem to play prominent role in their exposure to infection. Respondents to question during the examination of the individuals were of the opinion that though children at home and in school do not involve in major farm work where they could be exposed to drinking contaminated pond water, they do go to fetch water for domestic use and could as well drink from the pond water to satisfy their taste thereby getting infected. While the very old people vehemently refused to drink water from any other sources other than pond water which they believe tastes better than when it is boiled. Again, to them filtering of pond water before drinking wastes time, energy consuming and more so they believe that pond water is the only source of water bequated to them by their fathers. This relevant behavioural differences no doubt occured in most rural communities where there is no other source of drinking water other than polluted ponds and streams.

Actually, these people did not contact such infections from the boreholes but it was rather confirmed that they drank from untreated pond water the previous year before the boreholes were installed. A greater proportion of persons who depended on pond water had infections. Infected Cyclops are found in the ponds and when taken without filtering or boiling results in dracunculus infection. Few others who depended on seasonal streams were also infected. During the dry season months such seasonal streams stop flowing thereby creating stagnant water which serve as ponds along the water courses.

Third Stage Study May/June 2015

Result of the third stage study on evaluation of guinea worm infection status of after the proclaimed eradication guinea worm in Ebonyi State, Nigeria showed that out of the 1443 Cyclops evaluation in the study area, none was found infected in with guinea worm larvae. This implies that there is no more prevalence of infective guinea worm larvae in the communal water sources used by the people that could infect the abundant Cyclops habiting the water bodies. This is as a result of the eradication of guinea worm infection in the area. The abundance of Cyclops recorded in the first study 2004-2005, recorded monthly for 12 months was 5529 while the abundance of the Cyclops recorded in the third stage study May/June was 1443. Comparison of the abundance based on the number of months the study was carried out for each of the study show that the abundance of the Cyclops were more in the communal water sources after the eradication of Guinea worm disease in the state than before the eradication when eradication activities were in place. The reason for this could be that ponds were being treated with abate which controled the Cyclops population in the water bodies. But after the Guinea worm eradication, the ponds are no more being treated and the resultant effects are the explosion of the Cyclops population in the water bodies. This calls for serious attention by NIGEP and collaborating Agencies with view to ensuring more effective surveillance system for the disease after the eradication. The danger in this result is that introduction of any one case into the water bodies will led to explosive outbreak of the disease in the area. To guide against any outbreak of guinea worm disease again, the department of Parasitology and Entomology Nnamdi Azikiwe university Awka should be funded to carried out more research work on dracunculus and Cyclops density in our communities by the collaborating Agencies in Guinea worm eradication.

As a whole, the study revealed the followings:

- Dracunculiasis in the study area was independent of sex, age, religion and occupation and infection of human by guinea worm infected Cyclops was more dependent on behavioral differences and type of water sources available to the people for drinking.
- The incidence of guinea worm infected Cyclops and guinea worm disease are at its peak of transmission during the dry season months.
- Eradication of dracunculisis is possible as far as potable water is provided to endemic communities coupled with active health education.
- Early containment of cases and behavioral change are the effective ways that led to break of transmission. Problem observed was how to get farmers not to drink directly from infected ponds while working in the farm. Some of the ponds inside the farm lands were not detected by field workers for monthly treatment thus serve as reserviour or transmission site for dracunculiasis in the communities.
- Systematic abate treatment of water bodies was a major way out in the eradication where borehole or hand dug well could not be provided.
- The intervention activities of the five Organizations NIGEP, UNICEF, Global 2000, WHO and Yakubu Gowon Centre (YGC), the main supporters of the dracunculiasis eradication had positive impact on the eradication of the disease in the study area which led to eventual certification of Nigeria free of guinea worm disease.

RECOMMENDATIONS AND CONCLUSION

Intervention activities on guinea worm disease carried out in the state yielded positive result which led to proclaiming the state along with other states in Nigeria free of guinea worm disease by WHO in 2013. This was confirmed by the result of the third stage study in which no guinea infected Cyclops were recorded in the area studied. To make this gain enduring, the following recommendations are made:

1. **Surveillance:** There should be intensive surveillance of the guinea disease especially at the communities and village level by NIGEP with a view to ensuring early dictation any out break of the disease . The agency should be more equipped and monitored to ensure that there are carrying out the assigned responsibility. There should be more incentive or reward for the search of the guinea worm cases.
2. **Health Education**: Most of the community members have accepted health education aimed at avoiding contamination of water sources by infected persons, and prevention of drinking of unfiltered pond water. However small proportion of the community members who still persist in their belief and yet to accept the health education should continue to be educated.
3. **Distribution of Filters**: Not all the population in the study area had functional monofilament nylon filter materials for filtering their pond water before drinking. NIGEP and Global 2000 responsible for distribution of filters to the people should make more effort to supply filter to all households to ensure 100% filter coverage.
4. **Safe Water Supply**: Low coverage of the study area with safe water was observed in the course of this study. Most of the endemic villages visited for the study have only one hand

dug well (HDW) or borehole (BH) or none at all and these people depend solely on pond water which is the main source of dracunculiasis.

5. **Water Treatment with Abate**: The problem observed in this regard during study was inadequate trained personnel and logistics support. Efforts should be made to train and retrain more personnel's. Logistics support for field activities should be enhanced. There should be adequate supply of Abate chemicals and regular treatment of the water sources should be maintained so that the growing Cyclops population in the communual water bodies after fhe guinea worm eradication could be controlled.
6. **Cyclops Studies**: More researches should be carried out on Cyclops and Dracunculus and Sampling of all drinking water sources to assess the effect of Abate treatment on the Cyclops density should be a matter of routine measure.

In conclusion having proclaimed the state along with other states in Nigeria free of guinea worm disease by WHO and by the findings of this study in which none of the Cyclops encountered were found infected with guinea worm larvae, it is therefore confirmed that guinea worm disease has been eradicated in Ebonyi State.

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