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" THE GEOGRAPHY OF ONCHOCERCIASIS IN THE AMAZON BASIN "

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THE GEOGRAPHY OF ONCHOCERCIASIS IN THE AMAZON BASIN

Onchocerciasis has long been recognized as a major public health problem in the tropics, mainly in Africa but also in some American countries. It is of great economic importance, since it can not only force migration of people out of hyperendemic areas, with the consequent abandonment of productive lands, but can also discourage migrant labor into these regions.

A better understanding of the natural history and evolution of the disease in the Amazon is required if predictions with regard to its future significance are to be made. This seems to be a timely endeavour, since the region concerned, one of the most scarcely populated in South America, is likely to receive a sudden and uncontrolled influx of population in the near future, due to large scale economic activities now under way.

This essay is a preliminary analysis of the present distribution of onchocerciasis in the Amazon basin. It is an attempt to establish the present (if any) and past patterns of dispersion of this disease in the region. This requires the integration of epidemiological data on the foci existing today, with anthropo-geographical aspects of the Amazon, as well as with historical events.

Unfortunately, most of the basic epidemiological characteristics of the South American foci are still unknown. Moreover, due to the paucity of historical evidences that might have contributed to changes in the spatial distribution of the parasite, this essay should be considered merely an introduction to the study of the problem.

INTRODUCTION

The first autochtonous case of onchocerciasis in the Amazon region was reprted ten years ago (2). Some years later, MORAES et.al. (16;17;18) reported additional cases of the disease detected outside its places of origin. Local surveys more recently provided some indication of the prevalence rate of the parasite in the affected communities and in one local species of vector as well as a partial delimitation of the affected areas (19;22;23). BARRANCO (1) reviewed the general geographical aspects of the disease, before the endemic areas in the Amazon were known to exist.

The planned expansion of the highway system in the proximity of the endemic areas and the recent mobilization of great numbers of professionals for mineral prospecting in those areas has caused much concern (5;8;9;25). The disease has even been considered the most important health threat in the Amazon (9).

THE DISEASE

An overview of the pathology and the general aspects of the ecology of the disease is necessary for a proper appreciation of the problem.

Onchocerciasis is a parasitic disease caused by Onchocerca volvulus, a filarial worm. The adults live in the connective tissues of human beings, where they usually cause nodules. The adult worms do not affect human health very much; the most pathogenic effect is caused by the subcutaneous migration of the larvae to the eye tissue.

This causes lesions that produce serious loss of vision and eventual blindness.

The larvae of the parasite are transmitted to humans through the bite of blackflies of the genus Simulium. These blood-sucking insects breed only in fast-flowing watercourses, where the developmental stages occur. It is typically a chronic disease of rural populations and, more specifically, of persons living in communities located near watercourses.

Other than humans, no vertebrate hosts, either domestic or wild, are known to harbour the parasite . ~~According to the classification of MAY,~~ It is a three-factor complex, involving the parasite, the vector and the host. All of these are necessary, ~~therefore,~~ to maintain the endemicity of the disease.

There are some important biological features, of both parasite and vector, that must be kept in mind when considering the epidemiology and the migration of the disease. However, the biological data were obtained mostly from Africa where the problem has been more extensively studied; little is known about the ecology of the vectors and about the life-history of O. volvulus in the american countries.

The pre-patent period in the human host, that is, the interval between the innoculation of the infective larvae by the insect bite and the first appearance of the larvae of the following generation in the skin, is on the order of 5 to 20 months ; commonly 15 to 18.

The adult vectors have a life-span of 2 to 12 weeks and a flight range of 5 to 10 km from the breeding grounds; ~~12 km being the maximum distance recorded for an american species (20)~~.
After taking up larvae from the skin of an infected person, the vectors become infective within 6 to 12 days.

The adult worms can have a life-span of up to 15 years in the human host and the females produce larvae throughout their life. These can live under the skin from 6 to 30 months. The longevity of the worms, both adults and immatures, and the long pre-patent period are important factors when considering the dissemination of the disease. Large numbers of larvae survive in the skin without producing any symptoms or signs, and the individual is often unaware that he is infected.

Dissemination of the parasite to new areas usually takes place by movement of infected persons into places where previously uninfected Simulium populations were living. However, as the cycle of the disease is so long, a short-term visitor to infected communities may not be aware of the disease hazard. Human ecology therefor plays a major role in the maintenance and distribution of the disease. Instead of describing the advance of the disease as "virtually flying on the wings of the vector", as has been said (5), we would rather say " it is walking on the legs of the human host ".

The endemism of the disease, as well as the intensity and severity of infections, are less pronounced in northern South America than in Mexico, Central America and Africa. The prevalence in the communities is lower; blindness has been reported (but not confirmed) in a few cases, although subtle eye lesions are often present. The intensity of infections - measured by the number of larvae per mg. of skin snip - is also lower.

DISTRIBUTION IN THE NEW WORLD

Onchocerciasis was first reported in the new world in 1915, in Guatemala. After that, foci were identified for the first time in Mexico in 1925; in Venezuela in 1948; in Colombia in 1970 and, more recently, in Brazil (1972). In South America, up to the present time, Colombia has only one small focus in a village not far from the Pacific coast and Venezuela has two larger, separated foci, one in the north central and the other in the north eastern part of the country. Two isolated and unconfirmed cases have been reported, one in Ecuador (15), in 1953, and the other in

Surinam, in 1950 (10).

The well known foci in Brazil are located near the border of Venezuela, in the State of Amazonas and in the Federal Territory of Roraima. With the exception of three missionaries living in the area, all affected persons were indians of the Makiritare and Yanomamo groups. DAVIS (5), quoting a medical report of the brazilian National Indian Foundation (FUNAI), dated February 1975, mentions several other tribes of the upper Amazon as being infected. These included the Tucanos, Tikunas, Makus and Baniwas. According to the same document, the disease had already moved as far south as the States of Acre, Para and even to central-western Brazil. This situation was not known or perhaps recognized by the World Health Organization, since the last technical report by the expert committee on onchocerciasis, published in 1976, did not mention these areas as being endemic (31).

GEOGRAPHICAL CHARACTERIZATION OF THE AMAZONIAN FOCI

The Yanomamo, an estimated 10 to 15 thousand people today, live in some 125 scattered villages distributed over an area of approximately 30,000 square miles and partially overlapping the Makiritare territory (4; 27). This region includes the Parima river system and the upper Orinoco in Venezuela. The southernmost focus in Brazil is located in the northern part of the State of Amazonas, near the Toototobi river, a subtributary of the Rio Negro, at an elevation of 180 m. A second focus, also among the Yanomamos, was observed in the Surucucu mountains (830 m) in the western part of the Federal Territory of Roraima. The northernmost one is among villages of both Yanomamo and Makiritare indians, near the Auaris river (670 m) in the northwestern part of Roraima.

The region encompassed by the foci, known as the Parima highlands, is part of the Guiana Shield, of Pre-Cambrian origin, and has a mountainous granitic-gneissic relief. The soil is poorly known, but litosols and rock outcrops seems to predominate. It is covered with semi-deciduous forest; the relative humidity is high (annual average above 80%) and, although showers can come any time of the year, there is a short dry period of 1 to 2 months during the winter (from october to december). The annual rainfall ranges from 2000 to 2500 mm, with the number of rainy days ranging from 130 to 200 per year.

The coldest month of the year falls somewhere between February and July, but the temperature never drops below 15° C. The annual isotherm is 26° C.

The population density ranges from 0.08 to 0.1 inhab.(12;13) per square quilometer and the ethnic composition is predominantly mestizos (35 to 80 %), with a white population between 20 to 55 % and a black population of less than 20 %.

ORIGIN OF THE DISEASE IN THE NEW WORLD

A brief review of the controversial question of how and when the disease evolved in the american continent is not only of academic interest but also of practical importance in epidemiological considerations.

Two conflicting theories have been put forward in an attempt to explain the history of the american form of the parasite. The first one assumes that the disease was brought over from Africa – where it is now much more widespread and prevalent – along with the slave trade, either in colonial times or more recently. Several authors proposed different hypothesis in regard to the specific place and year of introduction. The estimated time of introduction ranges from the sixteenth century to the second half of last century and the initial place of entry is variously cited as southern Mexico, Guatemala or South America (7;28;30). These authors, however did not give any evidence to support their views other than historical records of the arrival of slaves in regions where onchocerciasis is now prevalent. These slaves alledgedly came from regions in Africa where the disease is presently endemic. The soundest evidence is given by TRAPIDO et. al. (30) in a study of the Colombian focus of the disease. This was found in a small settlement of black people lineally descended from slaves brought to the New World as early as 1590 to provide labor for the gold mining economy. Some of these infected persons bore surnames that could be identified with tribal areas of West Africa. The major flaw in this approach is the fact that although onchocerciasis is currently endemic in the places of origin of these slaves, these areas were not necessarily endemic centuries ago.This is an important point to be considered if one bears in mind the effect of the disease on the social structure and settlement patterns of rural communities. As has been observed in Africa (11), there is a critical level of incidence of blindness capable of dispersing people and producing cyclical movements of population in these areas.

Supporting evidence for the idea of the African origin of the parasite is found in the fact that two other filarial parasites of humans - Dipetalonema perstans and Wuchereria bancrofti - are widely accepted as having being introduced along with the slaves. These parasites are mostly distributed in the populations along the Atlantic coast of South America and the Caribbean, where most of the negroes arrived and settled.Logically, however, one is still forced to consider the following question: why did O. volvulus never get established in other areas of the New World, where many slaves where introduced and settled and where blackfly populations are known to occur ? (*)

Another interesting point is that if it can ever be demonstrated that the disease was introduced only once, into a

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(*) TORROELLA (29) recently quoted the record of a practising physician in the State of Bahia, Brazil, who observed in 1875 a skin disease caused by a worm described as " Filaria dersingle region, it will be much more difficult to explain the present pattern of distribution of the disease in the New World. There is a tremendous gap between the Central American focus and the Colombian focus, as well as a complete lack of contiguity between the Colombian, the Venezuelan and the Brazilian foci. This suggests an hypothesis of a " multiple " introduction of the parasite, that is, in several regions, possibly at different times.

The low intensity of infections in the South American foci, as compared to the African, Mexican and Guatemalan foci could be an indication of the recency of these foci. The introduction could have been directly from Africa or could have its origin in post-Columbian movements of people from Mexico and Central America. The latter view is reinforced by the experimental evidence obtained by DUKE (6) who observed a behavioral similarity between the Central american and the Venezuelan strains of the parasite.

The second main hypothesis holds that <u>O. volvulus</u> is autochtonous to the american continent and, therefore, has been in existence since pre-Columbian times. The idea is based on archaeological findings of the Zapoteca indians in Mexico, in one of the regions where onchocerciasis is endemic today. Skulls with perforations and sculptures with skin lesions attributed to <u>O.volvulus</u> were found. Opposing to this idea is the fact that penetration of the skull by an <u>Onchocerca</u> nodule is rare and that skull perforations and skin lesions can be produced by several other factors.

The most recent and important evidence in support of the idea of the indigenous nature of the parasite comes from the experimental works of LEON and DUKE (6;14). These authors observed that parasites of the African strains of <u>O.volvulus</u> are poorly adapted and do not develop to the infective stage in the

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matemica ". From the rather inadequate descriptions of the parasite and the clinical manifestations, he suggested that these " may well have been larvae of <u>O. volvulus</u> "

most important Central american and Venezuelan species of black fly vectors. This led him to the conclusion that the degree of adaptation of the african and american strains of the parasite to their respective vectors is the result of a prolongued and separate period of evolution, much longer than the relatively short period of some 400 years. Important consequences of distinct evolutionary histories could also be still undetected differences between the african and american strains of O.volvulus with regard to the susceptibility of the parasites to chemotherapeutic agents or even the duration of the various stages in the life history (14).

THE DISEASE IN THE AMAZON

Assuming that the introduction of O. volvulus from Africa is a valid hypothesis, the question of how the parasite got established among amerindians of a remote region of the Amazon with extremely low population densities and where no slaves were introduced remains to be considered.

The Yanomama are well known for the century old physical isolation of most of their communities. Most of the area they occupy is under their exclusive use and is essentially uninterrupted by alien cultures. They have even been considered to be " the fragmented remnants of the distribution pattern of the aboriginal population that once inhabited an enormous and diversified culture region, and representatives of a population thas was neither destroyed nor displaced " (27).

The first explanation was provided by MORAES (18;19), who thought that the disease was also endemic among the Venezuelan Yanomama. Thus, these indians would be responsible either for the redistribution of the disease in the brazilian territory or could act as sources of filarias for brazilian indians during the frequent movement of people to other villages. Indeed, during a survey conducted among the Yanomamo indians in Brazil, RASSI et. al. (22) found some infected visitors that were actually from Venezuelan villages. MORAES' opinion has recently been questioned by BEAVER et. al. (3) since they did not recognize onchocerciasis as a serious problem and found no evidence of a long established focus of the disease among the Venezuelan indians.

A second hypothesis was formulated by HANON (20). He mentioned that onchocerciasis foci might exist in the Guianas, historically a region of heavy slave traffic. ~~Indeed, VAN DER KUYP~~, in a personal communication to MALDONADO (30), had informed him of cases of the disease occurring in Surinam. Many slaves were known to have escaped into the forest and to have lived side-by-side with the indians. Thus, the close contact between onchocerciasis-carrying runaway slaves and american indians must be carefully examined. This hypothesis must be taken into account considering that Dipetalonema perstans was recently found among the Piaroa indians, settled near the juncture of the Orinoco and the Casiquiare river, close to the western limit of the Yanomamo culture area. Since this species, formerly restricted to coastal areas, was supposedly introduced by the slaves, these findings open another door for the investigation of the inland migration of filarial infections in South America.

A third hypothesis must be considered. Yanomamo could have acquired the parasite from the Makiritare indians with whom they have been in contact for more than a century, and with whom they even used to take up temporary residence for economic exchange. The Makiritare have long been in contact with civilization. Some of them are said to have made canoe trips as far east as Georgetown (Guyana) in the last century, to obtain steel tools. This could have brought them into contact with communities of african origin since the importation of slaves was an important activity in this region in the past.

The last and most remote possibility is that the parasite was introduced among the Yanomamo through contact with white people. Indeed, DUKE (20) suggested the possibility of missionaries acting as carriers of the parasite. Although the first contact of brazilian Yanomama with foreigners dates back to the eighteenth century , sustained intimate contact with non-indians was established just prior to 1960 (27). This happened in the upper Rio Toototobi, in the lowland periphery of Yanomama territory. Since then this has been their main zone of contact with foreign people. Perhaps coincidentally, this is the region where the most serious focus of the disease in Brazil is located. This area has the highest prevalence of the parasite in the communities and an increased intensity of individual infections as observed in the surveys of MORAES et. al (19) and RASSI et. al (23). There is also the possibility that the introduction of the parasite occurred after contact with non-indians beyond the eastern edge of the Yanomama domain. This seems however, highly unlikely, since this region is scarcely populated (23,500 people distributed over an area of about 230,000 square kilometers) (13), although a few occasional contacts with "garimpeiros" (folk miners) and even the appearance of bands of indians in the vicinity of Caracarai have been reported (24). Furthermore, this eastern part of the Territory of Roraima was found to be free of the disease in several localities surveyed (23).

Two other aspects concerning the characteristics of the disease in the Amazon should be considered: the absence of infection in several villages neighbouring the foci and the low incidence of infection in the affected tribes, as compared to rates of 100 % found in some african villages. The results obtained by RASSI et. al (23) seem to indicate that only those Yanomama tribes located in the mountainous region near the Brazilian- Venezuelan border have onchocerciasis. This is rather curious if one takes into account the dynamic distribution pattern and the Yanomama's frequent intervillage travelling for social visiting and trade. It has been observed that one individual is likely to visit about 25 different villages in his lifetime, covering an area of approximately 500 square miles. This sociability has already been reported as a major factor in the spread of epidemics among the indians themselves (26).

This lack of contiguity of infection among the villages and also the low intensity of infections led some authors to the conclusion that the brazilian foci could be relatively new and only now extending throughout this goup of indians. (3). This seems to be an adequate explanation if one considers that, as there is no multiplication of the young worms after innoculation into a human host, it only from repeated infections acquired over a considerable period of time that the population of the parasite in the boby can build up to high concentrations.

Another factor that could account for the low levels of infection could be the amount of contact between the host and the vector populations. Although no estimations of biting densities of blackflies in the endemic areas are available, they were observed to be lower in northern Amazonia than in the regions along the southern tributaries of the Amazon river (25). Even in the latter, the record of 250 bites/man/hour (21) is low compared to the 4000 bites/man/hour recorded in endemic regions in Africa. Moreover, contacts between blackflies and their hosts are not random. The zones where the parasite is transmitted is confined to the flight range of the parous female flies from its breeding sites. The Yanomamo, unlike most of the tropical forest cultures, are not riverine in orientation but sylvan people par excellance. They do not build effective craft for river navigation; they are essentially land travellers. This, and thefact that fishing is not a traditionally significant activity, keeps them from great exposure to the bites of Simulium and, therefore, from high transmission intensity.

It should be kept in mind that several other variables could be involved in the maintenance of low levels of infection, such as the immunological condition and genetic resistance of the host or the benign nature of the parasite strain involved.

The geographical distribution of the only proven vector species in the Amazon, S. amazonicum, should not be used as an argument to reinforce any theory on the dispersion of onchocerciasis, nor to make predictions as to the future spread of the parasite in the region ~~as has been recently attempted~~ (9;26). S. amazonicum has also been observed in Venezuela and Guyana and is widespread in the brazilian Amazonia but, as stressed before, human migration should be considerd the primary factor in the dissemination of the disease because, among other reasons, of the higher mobility of man in contrast to the low dispersion and strict dependence of the insect population upon well defined environmental factors.

One must also be aware of the possibility of the occurrence of distinct sub-specific forms, each with different behavioral and physiological characteristics, ecological requirements and, most important of all, different vectorial capacities, as already suggested (20). This phenomenon, observed in the most important african vectors of onchocerciasis, is thought to be responsible for the lack of clear cut correlation between the distribution of the black fly species and the distribution of the disease in that continent.

RESEARCH NEEDS

In the course of writing this paper, it has became clear that in order toachieve a better understanding of the historical development and present disease trends of onchocerciasis in the Amazon Basin, several areas of research must be investigated. These include the following:

* Broader field work on the ecology of the local vectors. Not even the time required for S. amazonicum to complete its life-history is known. Particularly important are data such as flight range and dispersion; biting habits; resting sites; seasonal variation of population numbers and the possible existence of ecological and genetic variants.

* An intensification of comparative epidemiological studies between the foci of onchocerciasis, both american and african. This would include, among other approaches, cross-transmission experiments and comparision of pathological findings.

* A more accurate mapping of the disease through epidemiological surveys among rural populations. These should concentrate primarily on communities surrounding the known foci and also on the semi-isolated black communities found in some areas of the continent.

* Historical research to obtain evidence for the presence of the disease in african countries at the time of the slave trade. Particularly useful sources might be the narratives of travels by the explorers and conquerors of the African continent. This should be followed by a geographical identification of the tribal origins of the different groups of slaves introduced in the New World. The inland migration and the settlement patterns of the negroes must also be investigated.

* Review of the anthropological data available in order to correlate the migrations and intertribal contacts between amerindians with the hypothesized patterns of diffusion of the disease. Past and present interethnic cotacts, both with black and white people, should also be investigated as possible causes of spread of the disease.

* Comparative epidemiological and ecological studies, as well as ethno-historical aspects of the dispersion of Mansonelosis, for the following reasons:

- it is a disease caused also by a filarial worm and vectored by the same blackfly species.

- it is autochtonous to the American continent and highly prevalent among Amazonian indians.

This could provide some insights concerning the most important factors likely to be involved in the dissemination of both diseases.

* An assesment of the possible effects of the present large scale environmental modification on the redistribution of the disease. This should be based on the examples observed in Africa, where man-made changes of the environment have had pronounced effects on the epidemiology of the disease. Projects involving water management, deforestation and also the concentration of human population in new areas should be carefully considered as factors capable of promoting the modification of landscape features restricting the foci of the disease.

CONCLUDING REMARKS

The important question remains to be answered: is onchocerciasis actively spreading and growing in incidence in the Amazon as has been alarmingly reported so many times in the past few years ? The answer could be either yes or no.

If a better understanding of the bionomics of the local vectors and of the natural history of the parasite, associated with more accurate epidemiological surveys and with anthropological and historical information, can definitely prove that O. volvulus has been introduced in the american continent, the answer is possibly yes.

On the other hand, if the autochtonous nature of the parasite is accepted, a more widespread but still unknown distribution of a mild strain (or even strains) of O. volvulus among native american populations is expected to be found.

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FIGURE 1 - Onchocerciasis foci in the Amazon Basin indians :

△ - reported by W.H.O.

▭ - unpublished information (FUNAI, Brazil) (see text)

Adapted from GOODLAND & IRWIN, 1975 (9).

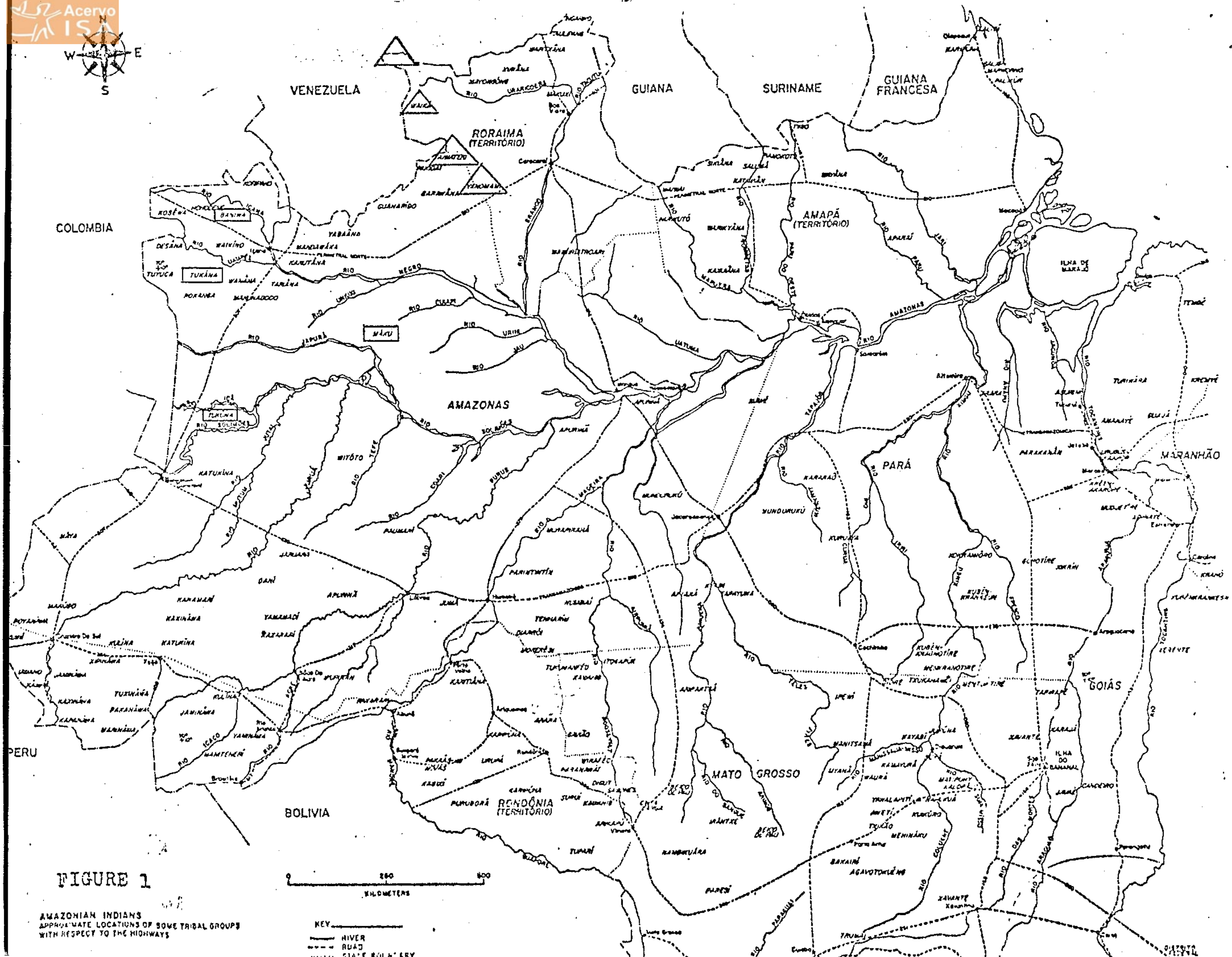
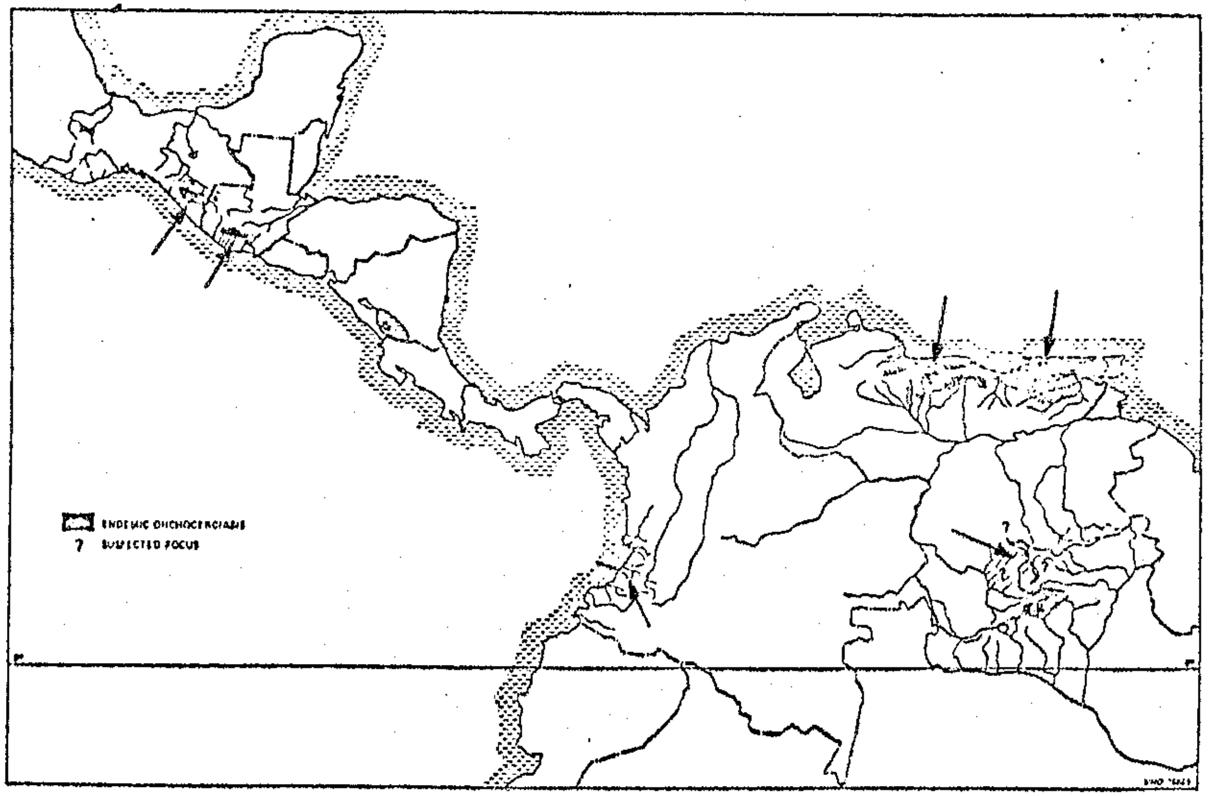


FIGURE 1

AMAZONIAN INDIANS
APPROXIMATE LOCATIONS OF SOME TRIBAL GROUPS WITH RESPECT TO THE HIGHWAYS

FIG. 2. GEOGRAPHICAL DISTRIBUTION OF ONCHOCERCIASIS IN THE WORLD: MEXICO AND CENTRAL AND SOUTH AMERICA



This map, prepared from information available to WHO at the end of 1975, gives an approximate picture of the main endemic areas as known from publications and reports. White areas do not necessarily indicate absence of disease; they may reflect lack of epidemiological information. Because of the small scale, individual foci within endemic areas are not shown.

From W.H.O., Technical Report Nº 597 (31)- 1976