INFECTIOUS DISEASES

Their Evolution and Eradication

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MALARIA - TROPICAL AFRICA

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Parasites

All four parasites of human malaria occur in tropical Africa (WHO, 1951 and 1963).

P.falciparum is usually the most prevalent all ever the continent as well as in all age groups, represented generally in 50 to 99 per cent of the positive blood slides. Its longevity inside the human body is longer than previously expected in Africa, reaching at least three years (Verdrager, 1964). Pyrimethamine- and proguanil-resistant strains of P.falciparum are very wide-spread all over tropical Africa (WHO, 1965).

P. malariae is very widespread, but less abundant than P. falciparum. In some restricted areas, generally where malaria transmission is not intense, P. malariae can occur in more than 50 % of the positive slides. Some pyrimethamine- and proguanil-resistant strains of P. malariae have been observed in East Africa (WHO, 1965).

P. vivax is extremely rare in West Africa, except perhaps along the Sahara border, but becomes more common in Central, East and Southern Africa, as well as in Madagascar and the Mascarene Islands. In several countries where it occurs, as in Kenya, it has a patchy distribution, being scarce in some areas and prevalent in some others (Bagster-Wilson, 1949). The scarcity of P. vivax in West Africa is apparently dependent on the insusceptibility of the native populations to this parasite (Bray, 1958) but this parasite has been observed in Europeans having spent some months in West Africa (WHO, 1963).

P. ovale is to be found in nearly all countries in Africa but with a varying incidence. It is infrequent in East Africa and in the hinterland of the continent ; it is more common in coastal and/or forested areas of West Africa, from Senegal to the Cameroons, where specific parasite rates up to 10 per cent have been recorded in restricted areas. P. ovale is more frequently encountered in children than in adults, (Lacan, 1965).

Vectors

Many African anopheline species have been involved in malaria transmission (De Meillon, 1947, 1951 ; Holstein, 1951), but no more than half a dozen are important vectors (Hamon et al., 1956 ; Hamon and Mouchet, 1961 ; Gillies, 1964).

Anopheles gambiae Giles appears now to be a complex of five sibling species (Davidson, 1964 ; Paterson, 1964). Both forms A and B of the complex are major malaria vectors, form A predominating in humid areas and form B in drier ones (Coz and Hamon, 1964), whereas form C is probably not a vector at all (Ramsdale, 1965). The brackish water form A. melas is a major vector of local importance, along the western coast, whereas its eastern representative, A. merus, is a poor vector along the coast of East Africa, Madagascar and Mascarene Islands (Iyengar, 1962).

A. gambiae s.l. occurs over almost all tropical Africa but not in some deserts, highlands, and extreme southern parts of the continent. It is particularly abundant in the open country and along large rivers in forested areas ; it exhibits large seasonal fluctuations whith peaks of density during the rainy season (Holstein, 1952). Dieldrin-resistant populations of forms A and B of A. gambiae complex are very widespread in West Africa, from Mauretania to Niger and to Congo-Brazzaville (Coz and Hamon, 1963) and some have been recently observed in Sudan and in Madagascar (Chauvet and Davidson, 1966).

A. funestus Giles is also a major malaria vector. It is very widespread but does not withstand extreme conditions as well as A. gambiae s.l.and does not occur in brackish coastal and inland waters, nor in arid areas. A. funestus predominates in savannah areas, with a peak of abundance at the end of the rainy season, and plays usually the main role for malaria transmission in mountainous areas and highlands. Dieldrin-resistant populations of A. funestus have been recently encountered in Nigeria and Ghana, West Africa (Service, 1964 ; Iyengar, 1965).

Some other anopheline species are vectors of local or regional importance, such a A. nili Theobald in the vicinity of rivers and streams in West and Central Africa, and A. moucheti Evans along large rivers of forested areas of Equatorial West Africa.

Sporozoite rates of both A. funestus and A. gambiae s.l. are fairly high, with monthly averages reaching 10 per cent and more at the peak of the transmission season, at least in lowlands areas. A. melas, A. nili and A. moucheti are less heavily infected but exhibit frequently, where they are vectors, sporozoite rates far above 1 per cent.

Distribution and Endemicity

General features of malaria distribution in tropical Africa have been summarized by Bagster-Wilson (1949) and in some working papers of the first conference on malaria in equatorial Africa (WHO, 1951). Since this period, many surveys have been carried out, increasing our knowledge, the most important contributions involving marginal areas and French-speaking countries (Barbie and Rouamba, 1964 ; Charles, 1962 ; Choumara, 1961 ; Escudie and Hamon, 1961 ; Languillon, 1957).

Malaria occurs in the whole of tropical Africa, except in Basutoland, southern parts of the Republic of South Africa, and some East African highlands ; in mountainous areas malaria is usually absent above 2,000 m. sea level in East Africa. In 1962 it was reckoned that amongst the 167,000,000 inhabitants of the WHO African Region (almost the whole of tropical Africa, except Ethiopia, Somalia and Sudan), 156,000,000 were, one day or another, carriers of malaria parasites.

In almost all lowland areas excepting very arid ones, malaria is very stable, even if transmission is seasonal ; morbidity and mortality are only conspicuous in the younger age groups of the human population ; older children and adults live in equilibrium with their parasites, with apparent absence of enlarged spleens, low parasite rates with a predominance of P. falciparum, and a very low parasite density (Bruce-Chwatt, 1962). In the highlands, at 1,400 m or more above sea level, malaria is often unstable. Epidemics almost always occur where malaria transmission is marginal, in arid areas, and/or at high elevations ; they are usually dependent either on exceptionally favorable weather (hot in highlands, rainy in arid areas), or on human interference with natural conditions (cultivation of swamps, road opening, labor migrations, and so on) (Meyus et al., 1962).

Accurate determination of the endemicity level, according to the Kampala classification (WHO, 1951), has been carried out only in some countries or groups of countries, and data are not always to hand. Recent unpublished surveys from Upper Volta and the Ivory Coast show that an almost identical endemicity level in different climatic areas can correspond to twenty infectives bites per man per year in one area, or to two-hundred in another ; furthermore, in the same area, the intensity of transmission can vary between less than three infectives bites per man per year in one village, and more than one thousand in another village, forty kilometers apart. Usually in lowlands, malaria is holoendemic or hyperendemic in wooded savannahs ; it is hyper- or mesoendemic in the forest and the steppe zones, and often also in coastal areas where brackish lagoons occur, as well as in many highlands areas ; along the Sahara border where the average annual rainfall is below 500 mm per year, malaria is meso- or hypoendemic.

Malaria Control in the Past

Until the end of the Second World War, collective malaria control in Africa was carried out through anopheline larval control, either by drainage or by larviciding. Individual protection was based on daily quinine absorption and bednetting (Bagster-Wilson, 1949). Regular pyrethrum extracts spraying has also been used on a very restricted basis.

Larval control, by drainage and water management, can be efficiently done against *A. funestus*, which uses mainly permanent or semi-permanent breeding-places, with vegetation, fresh water and some shade, but is very difficult to carry out against *A. gambiae* s.l. which breeds in temporary pools. Such a control was usually fairly successful during the dry season, but failed to control vector breeding during the rainy season.

Larval control by larviciding was also more easily applied against *A. funestus* which has a slow preimaginal development, and permanent breeding places, than against *A. gambiae* which has a very short larval cycle in favorable environment and inhabits ever-changing breeding places.

So, during the last World War, in the malarious parts of East and West Africa, in the absence of mepacrine treatment, despite large resources and competent teams, 25 to 50 per cent of the European troops got malaria in the course of a year, usually during the rainy season.

Protection of restricted communities, inside or near urban areas, was difficult and not entirely successful, and protection of African populations, scattered all over the bush, was impracticable. Everything changed with the discovery and mass production of residual synthetic insecticides and of powerful antimalarial drugs ; all specialists hoped that success was just at hand.

Malaria Control in Africa

Soon after the Second World War, DDT and BHC and later on dieldrin, became available in large quantities at reasonable prices. Since this period, malaria control in Africa has been mainly based on periodic applications of residual insecticides on all inner surfaces of houses and shelters. When vectors enter houses for feeding on human beings, they rest on the walls or on the ceiling, either before or after having their blood meal, or both, and they are supposed to be killed. Apparently the only problem to solve was a logistic one : how to spray all premises, at convenient dosages and intervals. In special instances, such as urban areas, larviciding was also widely improved by adding to the oil powerful synthetic insecticides and tensioactif agents.

The first African mass programs of insecticide house-spraying were carried out in Transvaal, Natal, Swaziland, and Mazoe Valley of Southern Rhodesia, with DDT or BHC, and in Madagascar with a mixture of DDT, BHC and Octochlor (WHO, 1951). More restricted malaria control programs were also carried out in Freetown, Sierra-Leone, by larviciding, and in Ilaro, South Nigeria, by BHC house-spraying (Bruce-Chwatt et al., 1955).

The First Conference on Malaria in Equatorial Africa held in Kampala, Uganda, in 1951, carried out a preliminary assesment of the results of these first malaria control programs. Results being promising, the Conference recommended the development of such programs in rural areas of tropical Africa, for promoting the social and economic development of the continent. Despite the restricted experience available at this time, the Conference recommended dosages and rhythms of application of insecticides some which are used up to now : either gamma- BHC every three months at 0,11 g/m2, or DDT every six months at 2,2 g/m2. Drugs were considered only for individual treatments, or for malaria prevention in restricted communities. The main objective of the programs was "a strong reduction of malaria transmission," and the words "malaria eradication" were never used (WHO, 1951).

During the following years several pilot-schemes and mass malaria control programs were organized either by national authorities alone (representing generally the European colonial powers), or by these authorities supported by the technical guidance of WHO and the financial help of UNICEF. These new programs were scattered all over Africa (Mauritius, Reunion, Kilimanjaro area, on the Kenya-Tanganyika border, South and North Cameroon, North-West Nigeria, South Dahomey, South Togo, West Upper Volta, Central Liberia, West Senegal) and the majority of them involved several combinations of insecticides, dosages and rhythms of application for selecting the most efficient one in each given environment. BHC and DDT were used first, rapidly followed by dieldrin.

The second African Conference of Malaria was held in Lagos in December 1955, offering a good opportunity for evaluating the results of all malaria control programs.

These results, as a whole, were disappointing ; almost nowhere was malaria transmission interrupted ; BHC has a too short residual effect to be of practical use in the majority of rural areas ; dieldrin was fairly efficient, but *Anopheles gambiae* populations were just becoming resistant to this insecticide in North-West Nigeria. Due to the inadequacy of the traditional methods of entomological evaluation and to acute scientific and technical understaffing of many programs, it was very difficult to explain the persistence of transmission in almost all treated areas. Nevertheless it became obvious that insecticides alone would not always succeed in controlling malaria transmission, and that drug administration could be a valuable addition to house-spraying.

Complementary evaluations of the malaria control programs, and improvement of the qualifications and experience of the responsible malariologists and entomologists, were carried out during the following years until 1959, through WHO-sponsored sub-regional malaria meetings and training seminars.

Malaria Eradication

Despite the difficulties of malaria control operations in tropical Africa, malaria eradication soon became the official goal of WHO for this continent, as a part of the worldwide malaria eradication program. Control operations are endless and, in poor countries, eradication could appear as the cheapest way to be rid of malaria.

Almost all programs, with WHO advice and sometimes material help, were reevaluated and replanned, to get efficient spraying, complete coverage, better case detection, and so on. This involved, in the majority of treated areas, a complementary training of personnel, the establishment of more accurate maps than available with the precise location of all huts and tracks, the individual recording of all inhabitants and of their seasonal migrations when occurring, as well as the development of laboratory facilities for rapid mass examination of blood slides and malaria parasite detection.

Experiments of mass chemotherapy were undertaken, associated or not with insecticide spraying, involving various methods and drugs, including individual distribution, collective distribution to village headmen, Pinotti's method, pyrimethamine, 4-amino- and 8-aminoquinoleines (WHO, 1963).

Evaluation of almost all African malaria control and malaria eradication programs has been recently carried out either during the Third African Conference on Malaria, held in Yaounde in July 1962 (WHO, 1963), or through mimeographied reports and published papers.

Satisfactory results, apparently of a permanent nature, have been reported from South Africa, Swaziland (Mastbaum, 1957 a and b), parts of Southern Rhodesia (Alves and Blair, 1955 ; Wolfe, 1964), Mauritius (Verdrager, 1964), parts of Uganda Highlands (Zulueta et al., 1961, 1964), Madagascar Highlands (Bernard, 1963). However, according to WHO (1965), the consolidation phase has been reached only in South Africa, Swaziland, and Mauritius, involving about five million inhabitants amongst the 190 million living in malarious areas for the whole African continent.

All successes but one have been observed in marginal areas of malaria transmission, either for altitude, or for latitude, or both. Besides, in Madagascar and Uganda malaria eradication has reached a dead end for lack of sufficient financial support.

Satisfactory results, of a very temporary nature, have been recorded in forested areas from South Cameroon (Livadas et al., 1958) and Central Liberia (WHO, 1963). Transmission has been apparently interrupted, but both projects did not reach the consolidation phase and, at least in the first area, transmission has resumed soon after the interruption of spraying activities, due to the inefficacy of the case-detection organization.

In both areas A. gambiae "A" was the main vector and the only host available was man, sleeping all night inside houses. It must be also noted that, in forest areas, the relative humidity is always high, which increases the efficacy of DDT deposits of mud surfaces. However, according to reliable reports, small, not easily detected, residual foci of malaria were never eradicated from both areas ; these foci were constituted by individual huts or very small hamlets, including temporary ones, scattered in the bush, for mining, hunting, fishing, and cropraising activities, sometimes of an unlawful nature (such as diamond smuggling and so on).

All other African schemes have failed to interrupt malaria transmission, and for some of them discussion of the situation has been published in full length : North Cameroon (Cavalie and Mouchet, 1961, 1962), Upper Volta (Choumara et al., 1959 ; Escudie et al., 1962), North-West Nigeria (Dodge, 1962, 1965), Kenya-Tanganyika border (Anonymous, 1960 a and b). Further details about the other projects can be found in WHO reports (WHO, 1963).

All these schemes were characterized by holo- or hyperendemic malaria in savannah areas, or at least non-forested areas, with humans and cattle and sometimes also game mixed. In these countries the residual insecticide spraying operations, sometimes combined with chemoprophylaxis, resulted in a marked regression of spleen and parasite rates, but a limit has been reached at which, in spite of repeated efforts, malaria has persisted to a noticeable degree.

In some of these projects the quality of operations reached a very high standard, in some other schemes the insecticide coverage was not perfect but reached the maximum permissible in the local conditions, and the situation could only worsen in larger schemes. So all these unsuccessful projects have been abandoned.

WHO has recognized that tropical Africa is not ready for malaria eradication. In some countries it is technically possible to interrupt transmission, but not to organize the consolidation operations ; in some other countries both are possible, but neighboring states are not ready, and movement of populations, or lack of financial support delay the programs ; in more countries it has not been proven possible to interrupt transmission, and staff and laboratory facilities, as well as financial support, are lacking.

In these conditions WHO has recommended, during pre-eradication programs, the development of administrative and technical infrastructures enabling the countries to carry on malaria eradication in the future on a regional or continental basis. The pre-eradication programs, which have no time limits, are developing in about twenty countries of the WHO African region (WHO, 1965).

As already stressed, the only successes in African malaria eradication schemes have been reported from marginal areas and from a small and densely populated island, Mauritius, which have reached the maintenance phase. We shall then examine the main causes of failure of the other schemes, which can be listed under three main headings : technical, logistic, and administrative and economic causes.

Technical Difficulties

1. The Vectors. In the main parts of tropical African environmental conditions are very favorable for malaria transmission ; the outside average temperature is always sufficient for the completion of any human plasmodium extrinsic cycle ; in almost all areas but high forest zones, either cattle, or game, or both, are present, and vectors can feed upon them without entering houses ; further-more, the natural longevity of the main vectors, *A. funestus* and *A. gambiae* s.l., is one of the highest recorded in the world for anophelines. Female vectors may bite humans only occasionally, rest outside, and nevertheless ensure malaria transmission with a minimum of contact with insecticide-treated premises. The insecticide spraying must reach a very high degree of efficacy to interrupt the malaria transmission in lowlands of tropical Africa.

The first difficulties appeared with dieldrin-resistance in members of *A. gambiae* complex. Dieldrin is a good insecticide, longlasting even on mud walls, but entirely useless against dieldrin-resistant populations. In such conditions gamma-BHC cannot control economically the transmission and in the whole of West Africa the only available insecticide for anopheline control is DDT. Besides dieldrin-resistance not only occurs in dieldrin and BHC treated schemes, but exists almost everywhere in West Africa, having been induced by agricultural applications of chemically related compounds, or of BHC ; it is also now appearing in East Africa and Madagascar (Coz and Hamon, 1963 ; Chauvet and Davidson, 1966).

DDT in itself is a very safe and powerful insecticide, but with mosquito-irritant properties ; mosquitoes settle for short periods only on DDT-treated surfaces and leave them very often without acquiring a lethal dose of the toxicant ; this phenomenon is very conspicuous with females of A. gambiae s.l. which are relatively tolerant to DDT and occurs also, to a lesser extent, with the more susceptible A. funestus females (Kuhlow, 1962 ; Mouchet and Cavalie, 1961 ; Service, 1964). The irritant properties of DDT are almost independent of the dose, so fresh deposits irritate vectors, but kill them, whereas, some months older deposits do not kill them (Coz et al., 1965). This DDT characteristic is not very harmful in environments where huts constitute the only convenient anopheline resting place, or where humans offer the only blood source available and sleep inside houses, such as respectively in highlands with a cool climate, or in forested areas almost without any other large mammalian host, but it reduces the efficacy of DDT when and where outside resting places and convenient hosts are available, such as in the majority of lowland savannahs.

Furthermore, in areas with a dry and hot climate humans spend a part of the night sleeping outside, offering a perfect opportunity for vectors to feed upon them without any contact with the insecticides. This situation is exaggerated by the natural tendencies of many populations of A. funestus and A. gambiae s.l. for exophagy and exophily, and even more when such an exophilic vector as A. nili is involved. Such situations occur mainly in Sudanese savannahs and sahelian areas.

With new and better insecticides, it could be possible to overcome difficulties due to insecticide-resistance and vector-irritability. But in tropical Africa many houses are built with raw mud bricks, and even roofs can be mud-made, and so sorption is a big technical problem. A good insecticide for African bush use, amongst other qualities, must be nontoxic for mammals, chemically and physically stable on mud surfaces, nonirritant and noninducing resistance. In spite of a collective researche program sponsored by WHO and other agencies, no such insecticide is yet available (Foll et al., 1965 ; Gratz and Carmichael, 1962 ; Gratz et al., 1963 ; Hamon et al., 1965 ; Smith and Hocking, 1963 ; Bar-Zeev and Bracha, 1965 ; Anonyme, 1964 ; Elliott et al., 1963).

2. The Parasites. Mass chemical control of the malaria parasites, in developing countries, can only be based on safe and moderately long lasting compounds, preferably preventing mosquito infection. Pyrimethamine is long-lasting, but not very safe, and besides has induced the selection of resistant strains of *P. falciparum* all over Africa. Four-aminoquinoleines are much safer but their efficacy is reduced to a few days following their absorption. Pinotti's method is not an answer, pyrimethamine inducing resistance, 4-aminoquinoleines not passing through the mother milk for ensuring baby protection, and local sources of salt being available in many areas of tropical Africa. So results of almost all mass drug distributions have been disappointing (WHO, 1963 ; Clyde, 1962 ; Escudie, et al., 1961, 1962).

3. Logistic Difficulties. Some parts of South-East Africa are already developed, but the largest part of tropical Africa is just developing. Logistic facilities, which are normally expected in temperate countries, barely exist in many areas of the African hinterland.

Maps are usually medium-scale ones, where only villages and hamlets are represented and on which road and track viability practically is not recorded. A large proportion of them are too old to be very accurate, and the oldest are entirely worthless. All preliminary surveys must include a large geographic recognition, to assess the value of the available maps and to improve them, and sometimes to replace them by complete remapping of the program area. This work requires specialists who do not exist and must be trained on the spot. Furthermore, in rapidly developing areas, maps lose their accuracy every year.

In the majority of African countries only a few roads of major importance are practicable all the year round. Secondary roads and tracks very often are cut off during each rainy season. In many areas, only four-wheel drive vehicles can be used in the dry season, and villages are unreachable for the whole of the rainy season, except by walking, horse or camel riding, or bicycling. In some areas, mapped secondary roads are even cultivated during the rainy season.

In such conditions, insecticide-spraying activities must be concentrated just before and just after the rainy season, no more than two cycles per year being permissible. The spraying of new structures during the rainy season is very difficult and, when possible, is carried out without supervision. Regular blood-slide collection, case detection, and drug distribution are almost impossible to carry out on large areas during the main malaria transmission season.

Any malaria eradication scheme implies a complete census of the population. In several African countries, capitation taxes paid by each adult independently of his wealth are always in use ; as long as inhabitants may escape registration the avoid paying taxes, and in such countries birth and even death registrations are fairly inaccurate. The situation is worse when nomads are involved, as even their nationality may vary from year to year according to rainfall, or to relative variation of the cattle tax between neighboring states.

In many areas the population density is low or very low, between 10 and 0.1 inhabitants per square kilometer. So dispensaries are out of reach of the inhabitants, and vice versa, rendering house-spraying, drug distribution, and case detection very costly.

In the driest parts of tropical Africa the majority of inhabitants are nomadic, and travel all the year round with their cattle hundreds and even thousands of kilometers (Barbie and Rouamba, 1964 ; Visser, 1965). Nomads constitute also a small proportion of savannah inhabitants, and travel huge distances through savannah and forest to sell their cattle down to the coast.

Seasonal nomadism occurs also in sedentary agricultural populations. In the absence of any manure and fertilisers, the soil fertility decreases sharply after two to four years of consecutive cultivation, so cultivated fields are abandoned for new ones. Villages are generally perfectly stable, but in many areas each family moves during the rainy season to a temporary house, erected in the immediate vicinity of the crops ; the inhabitants may spend only some days a week in their "farm", but they may also abandon their village for several months, taking with them goats, poultry, and so on. Every year a large proportion of these "farms" are abandoned and new ones are built, some kilometers apart. This system ensures a maximum contact between vectors and humans, and a minimum contact between inhabitants and administrative authorities, during the main malaria transmission season.

Furthermore, in many savannah areas, where soil is poor, but population abundant, young men leave their villages some months, a year or more, to seek a paid job hundreds of kilometers away, in the richer coastal or forested neighboring areas, working as laborers on coffee or cocoa estates, on roadwork, or on industrial plants. They are usually not registered at all where they work, and move by foot on long distances, eventually acquiring and disseminating parasites along the way (Prothero, 1961).

The majority of houses, in rural areas of tropical Africa, are built from poles, thatch, mud, palm leaves, and other locally available materials. Stones, concrete, bricks, and corrugated iron are rarely used. Such houses have to be repaired or rebuilt at frequent intervals.

Poles and thatch houses suffer from injuries by mining insects, white ants and fungi ; the roof at least must be changed every two or three years. Mud houses are less fragile, but poles supporting the roof rot with time, and when the mud is too sandy a large proportion of roofs and walls collapse during the rainy season. So each year on one hand all houses too damaged to be repaired are partly or entirely rebuilt, usually during the dry season, whereas during the rainy season all damaged structures are restored by thatch and poles adding, remudding and replastering, and so on. Such processes maintain in treated villages a variable proportion of unsprayed houses or, at least, of untreated surfaces. Furthermore, the villages can only be efficiently sprayed after the completion of the seasonal rebuilding which, in many situations, ends only shortly before the rainy season ; it is even of common occurence to repair or build the temporary field houses during the first half of the rainy season which prevents their spraying before the beginning of the transmission season and increases sharply the proportion of untreated premises.

Temporary houses scattered through the bush for cultivation, fishing, or hunting purposes are more lightly built than the village ones and must very often be rebuilt or replastered some months after their building. They offer more opportunities to mosquito entrance and exit than normal houses.

4. Administrative and Economic Difficulties. Last, but not least, tropical Africa is not a wealthy area. All states are developing their general infrastructure and they simply cannot focus their restricted income on non-time-limited malaria eradication programs and they wonder if it would be worthwhile to carry it on, even if money were available.

Malaria is endemic in large areas of tropical Africa, with adults semi-immune to the disease, and there malaria does not appear of primary socioeconomic importance.

Older children and adults, who constitute the man power, rarely suffer from the disease to such an extent that they must interrupt their work, and the country's productivity is not sharply affected by malaria. Diseases killing adults, or decreasing conspicuously their working efficacy, such as sleeping-sickness, onchocerciasis, Wuchereria filariasis, leprosy, are more noticeable and appear easily more important than malaria to administrative authorities as well as to many medical specialists.

The main importance of malaria is the depletion of the youngest, non-immune age groups, but is not so noticeable in the presence of smallpox, measles, enteritis, yaws, yellow fever, and other diseases which kill so many babies and children every year, or will kill them if mass vaccination is not yearly carried out by mobile units.

Furthermore, the majority of the inhabitants are scattered in innumerable bush villages and hamlets and, when mildly sick, they do not attend a dispensary, they do not take any commercial drug, but wait and recover spontaneously or die. Only some of the acute cases, eventually, will reach a nurse or a doctor, receive drugs, and cost something to the state budget.

As a whole tropical Africa is understaffed, always in quantity, sometimes in quality, sometimes in both, according to the country involved.

Highly qualified specialists are very scarce. Very often they perform important political or administrative jobs, without direct relationship with their previous training and qualification, because they are the only ones available.

Medium qualified staff is scarcely more easily available in large numbers, and the level of training is usually far from satisfactory, due to the lack of training facilities in the recent past. Besides, for this category private business often offers better wages or more rapid promotion opportunities than administrative agencies and, at least in the richest countries, the smartest boys are not specially attracted by public jobs.

Unqualified workers are plentiful, but their instruction level is very low ; they must be carefully trained before use. Their official wages are also very low, and administrative rules do not facilitate the rapid promotion of the best workers, or the dismissal of the bad ones. As a result, the best elements, when well trained often seek another job, whereas bad ones stick to the public service.

The lack of political stability, even in the absence of riots or of uprisings, is a complicating factor for staffing and planning any long term program, such as malaria eradication.

The Future of Malaria Eradication in Tropical Africa.

Difficulties encountered in tropical Africa for organising malaria eradication programs have been met in many other tropical countries, in the so called "problem areas," the difference is not so much a matter of nature as a matter of magnitude ; for malaria eradication, tropical Africa constitutes a "problem continent".

All the observations made above lead to the conclusion that, as a whole, tropical Africa is not ready for eradication and should still today confine itself to pre-eradication programs. During the development of these programs, better drugs and insecticides will probably be discovered and, with time, we must succeed in improving the administrative and technical infrastructure of African countries. This will enable them, in the remote future, to undertake malaria eradication on a continental, or at least on a regional basis, probably paid for by more developed countries or by international organizations. Due to the very uneven development of neighboring states, and to the lack of natural boundaries preventing the immigration of malaria parasites, malaria eradication at a national level will rarely be recommendable, if even possible (Bernard, 1963).

These views may appear too pessimistic. If so, we must remember that a small skin-scraping every three years is sufficient to prevent smallpox in humans yet after half a century we are still unable to eradicate smallpox from Africa ; we must note also that one pentamidine injection every six months is sufficient to protect against gambiense sleeping-sickness, but that we have not succeeded during the fifteen years that the compound is available and widely used, in eradicating this disease. These few examples, amongst many possible ones, must recall us to moderation and modesty.

Waiting for malaria eradication will not be a synonym for indifference to malaria. So, for years, it might be necessary to give priority to activities intended to control this disease, either through imagocide or antilarval measures, or through the reduction of the parasite reservoir, when and where the situation is favorable. It is very probable that such malaria control activities will develop more and more with the passing years, restoring more or less the situation and state of mind observed in the most developed countries of tropical Africa before the launching of the WHO-sponsored malaria eradication programs.

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