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PROBLEMS OF MALARIA CONTROL IN TROPICAL AFRICA

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Three years ago the introductory sentence of an excellent world-wide review of modern methods of malaria control read as follows: "Into Africa—perhaps the most malaria-ridden of all continents—modern methods of control by residual insecticides were introduced at a late date and on a small scale" (Pampana, 1951). It will be only fair to admit that during the past few years there has been no radical improvement of the situation in tropical Africa. Although there are to-day many signs of forthcoming changes, it might be of value to outline the main reasons for the hitherto slow progress of malaria control in Africa south of the Sahara.

Two years ago one of our greatest living malariologists, at the end of his extensive journey through East and Central Africa, said: "There is nothing mysterious about African malaria; it is only the size of the problem that is different." This is true, but the quantitative difference is so great that it imparts to African malaria several exceptional characteristics.

The speed with which we can reach the objective of achieving and maintaining better standards of public health depends in the first place on the knowledge of the causes and conditions that favour the spread of communicable diseases. Secondly, there must be the will, the means, and the favourable environment to apply the existing knowledge in order to promote health.

We know that malaria can be eliminated either by attacking the parasite or by dealing with the insect vector. A nearly perfect degree of malaria control can be achieved by chemotherapy and chemoprophylaxis in organized communities or under supervision. A similar degree of malaria control in ordinary communities in tropical areas has never been attained, mainly because of practical difficulties in regular drug administration. It seems, however, that the new anti-malarials (chloroquine, pyrimethamine) may open new possibilities of chemotherapeutic control of malaria. An interesting example of this new trend is the mass-administration in Brazil (Pinotti, 1953) of chloroquine incorporated into common salt distributed by a government agency. Nevertheless, the general consensus of opinion is still overwhelmingly in favour of malaria control by attacking the anopheline vector, preferably by the use of residual insecticides.

The following factors are of importance in considering malaria control by residual insecticides in tropical Africa: (1) Knowledge of the amount and distribution of malaria and of the importance of this disease from the point of view of public health; (2) knowledge of the

natural history of the disease, particularly with reference to its insect vector; (3) technical knowledge of the action and methods of application of residual insecticides, particularly in rural areas; (4) economic possibility of carrying out a large-scale malaria control on a long-term basis, first as a special project, but as soon as possible within a framework of general health services of the country; and (5) sociological background for malaria control and its possible future implications. An analysis of each of these factors, with reference to tropical Africa generally but on a basis of personal experience mainly in West Africa, gives the following results.

1. Malaria in Tropical Africa

Our knowledge of the amount and distribution of malaria in tropical Africa is still woefully inadequate. The blame for the lack of general information on morbidity and mortality due to malaria is often ascribed to medical administrators, but the conditions in tropical Africa are particularly difficult. With an average of one qualified medical practitioner to 90,000 inhabitants and one hospital bed to 3,000 inhabitants, only a small proportion of the African population has the benefit of medical attention. But even when the medical officer is available the malaria morbidity records are far from adequate, since the diagnosis of this disease in Africa leaves a wide margin for personal interpretation of clinical symptoms and of laboratory data.

Some striking differences between two successive annual rates of malaria in the same locality could be traced to a change of medical officers who had different ideas on the diagnosis of this disease.

It is only recently that investigations carried out in Nigeria estimated that the age-specific malaria mortality figures expressed per 1,000 Africans exposed to risk were as high as 12.5 in infants, 7 in small children, and much lower (about 0.5) in older children, adolescents, and adults. If these malaria mortalities hold good for the rest of tropical Africa, with its 150 million inhabitants, it means that in this part of the world at least 175,000 children below the age of 15 die every year from the direct effects of the disease. The amount of morbidity due to malaria is so imperfectly known that even an approximate estimate of it would be merely a guess. In the absence of reliable biostatistical records the classical malariometrical indices provide a guide, but some of these indices, based mainly on experience in other parts of the world (India), can be misleading if applied uncritically to African conditions, and might have to be amended.

Any comprehensive malaria-control project must therefore be provided with a yardstick by means of which the efficacy of adopted methods can be assessed. Since clinical morbidity statistics are not available and biostatistical records cannot be compared with previous data, which do not exist,

the only thing that remains is a constant and critical checking of malariometrical indices by an ancillary survey organization initially forming a part of the control project and later remaining as a permanent feature of a mobile field unit dealing with rural public health. Wherever impressions are substituted for facts they are usually favourably biased in projects which are expensive and regarding which there is an understandable and perhaps subconscious desire to show good results for expended money.

The results reported from Mauritius (Dowling, 1953) have shown that moderately endemic malaria can be eliminated within a relatively short time by a residual spraying campaign. Similar though not so convincing results were reported from other African areas with epidemic or hyperendemic malaria. The results of the Ilaro scheme in Nigeria are interesting. There, a continuous though not quite complete control of two main vectors within a small holoendemic area changed in three years the picture of the local malaria to a surprising degree. If such results can be achieved in a small area, supersaturated with malaria, surrounded by a dense tropical forest, with a long period of transmission, then there is little doubt that equally good or better results could be expected from larger and more sustained projects (Bruce-Chwatt *et al.*, 1953).

The imperfect knowledge of the true parasite-host relationship in African malaria is the root of the controversial problem whether it is advisable to control malaria in holoendemic and hyperendemic areas where the community has achieved a high degree of tolerance to the parasite at a cost of considerable mortality of its youngest members. We still do not know what part the acquired defence mechanism plays in the group tolerance to superinfection and how far it must be considered in conditions when eradication of the vector species without a chance of reimportation or a permanent malaria control over a wide area cannot be guaranteed (Maegraith, 1950).

Are we justified in concentrating on localized malaria control for the benefit of those continuously protected but who run a risk of their reinfections becoming more serious should they become accidentally exposed to it? Would it be wise to embark lightly in holoendemic areas of tropical Africa upon unrestricted measures of malaria control? What would happen if the control over a large area broke down because of a financial slump, difficulty in obtaining supplies of insecticide, or political unrest? Would the vector sweep the country and cause outbreaks of malaria, with a high fatality rate in the younger generations (Wilson, Garnham, and Swellengrebel, 1950)?

Our present state of knowledge is still inadequate to answer those haunting questions. It must be realized, however, that the possibilities of detrimental effects of incomplete malaria control are somewhat theoretical, and not confirmed by any reliable observations. The problem will not be decided until we have more basic data to work upon instead of arguments often derived from the personal philosophy of their proponents.

Whatever the future solution, it seems to-day that as a result of recommendations of the Kampala Conference (W.H.O., 1951) there is throughout tropical Africa a welcome and growing awareness of the need for pilot malaria control, whatever the original degree of endemicity.

2. The Anopheline Vectors of Malaria in Tropical Africa

Of the 30 species and varieties of Ethiopian anophelini only 11 can be regarded as vectors of human malaria. Seven of these (*A. brunnipes*, *A. hancocki*, *A. hargreavesi*, *A. moucheti*, *A. nili*, *A. pharoensis*, *A. rufipes*) are of some local importance in areas where and when the main vectors are rare. The part played by the secondary vectors is, however, insignificant in comparison with the continent-wide amount of transmission of malaria by *A. funestus* and *A. gambiae* (including *A. gambiae melas*). There is little doubt, therefore, that with some local exceptions the con-

trol of malaria by residual insecticides must be concentrated on the two main vectors, which are both characterized (though not to the same degree) by their wide distribution, predominantly house-haunting (endophilic) and man-biting (anthropophilic) habits, and high infective potential. All these factors comprise what Gabaldon (1953) calls the "vectorial power."

A. funestus has always been regarded as essentially endophilic and anthropophilic with a relatively stable breeding potential and fixed habits. It was therefore anticipated that residual insecticides would be highly successful in the control of this mosquito. The results did not deceive the expectations. Reports available from Madagascar, from Mauritius, from the Belgian Congo, and from Nigeria are particularly striking in their similarity. Whatever residual insecticide was used the density of *A. funestus* in these areas decreased with a spectacular speed and bordered on eradication, with a concomitant decrease of malaria transmission. These results would not have been achieved if the species concerned could either change its habits or produce any number of bionomically varying strains.

In contradistinction to the experience with *A. funestus*, the results recorded with *A. gambiae* in similar malaria-control schemes in tropical Africa varied most unpredictably. Methods that eliminated *A. funestus* from Mauritius and Madagascar have not succeeded in doing so to *A. gambiae* in these two islands, though the species concerned was reduced to small numbers and has apparently ceased to invade the human habitations and to transmit malaria. In a small-scale experimental scheme in Nigeria the density of *A. gambiae* decreased very greatly, but a certain amount of malaria transmission was still occurring. In the Belgian Congo, Ruanda-Urundi, and Southern Rhodesia the density of this mosquito decreased so much that the transmission was cut down to a very low level, but there was no evidence of the change of habits of the species. In Freetown the use of residual insecticides to improve still further the good results of a larvicidal scheme reduced *A. gambiae* density to extremely low levels but did not eliminate it entirely. On the other hand, in an experimental area in East Africa (Kasanje) and in Swaziland there was relatively little difference between the results of surveys carried out before and after the application of residual insecticides for over two years. In Transvaal, in a sparsely inhabited large rural area, a well-organized control by residual insecticides was very effective for six years, during which the rainfall was not unduly heavy, but one exceptionally rainy year proved the imagocidal control to be insufficient and led to a considerable influx of *A. gambiae*, which had to be dealt with by additional larvicidal measures (Annecke, 1953).

The inconsistency of results reported from various parts of tropical Africa cannot be fully explained by the differences in the size of the area, climatic conditions, type of the insecticide, method of its application, etc. It seems that at least some of the divergencies are due to our ignorance of the bionomics of *A. gambiae*, and particularly of the subtle interplay between the habits of this mosquito, its longevity, and macroclimatic and microclimatic conditions of the environment.

Habits of *A. gambiae*

A. gambiae was known to be the most man-linked malaria vector in tropical Africa, and yet it has been shown that it can be found in great numbers in dense, uninhabited forests of East and West Africa, that it might feed in nature on various animals as well as on man, that it can be induced to do so in a laboratory colony, that it might feed indoors and out of doors, that it can use for a shelter not only human or animal dwellings but also natural haunts, and that its infectivity may vary greatly from season to season in one area or from one area to another during the same season.

It might be that *A. gambiae* is either a species with a most remarkable plasticity which undermines the present concept of physiological races or perhaps it is really a

species complex with at least two cryptic subspecies (Holstein, 1952) and many varieties with bionomical differences, particularly with regard to their preferential feeding habits. These differences, however, will have an epidemiological significance only when confirmed by similar differences of the infectivity of the subspecies concerned.

The apparent differences in feeding habits of *A. gambiae* might, on the other hand, be explained in a simpler way, as suggested by Muirhead-Thomson (1951). It has been shown that in this species some of the females may rest in houses after the blood-meal, while a proportion will leave the house at this stage and rest out of doors. The less suitable the feeding site as a daytime resting place the higher the number of mosquitoes which will leave after feeding. While many human dwellings provide suitable daytime shelters, many domestic animals are kept in exposed structures, so that mosquitoes feeding there at night seek daytime shelters elsewhere. Thus precipitin tests on the blood found in the stomachs of anopheles collected out of doors will reveal a high proportion of animal bloods, even though the bulk of the mosquito population feeds preferentially on man.

All these obvious gaps in our knowledge of the habits of the main malaria vector in Africa prevent the rational and systematic application of available techniques of control by residual insecticides. This knowledge might be ultimately more important for the future of malaria control than many data on the physical and chemical properties of insecticides.

3. Residual Insecticides in Tropical Africa

In spite of the fact that large-scale use of D.D.T. for malaria control dates from 1944, our present knowledge of technical problems associated with the choice of the residual insecticide, its adequate dosage, best formulation, duration of adequate toxicity to mosquitoes, and any danger to man and his animals is in a state of flux which makes any large-scale planning of malaria control rather difficult.

It is a matter of regret that the published reports of laboratory and field investigations show a disconcerting lack of agreement on the significance of their results. This indicates perhaps the importance of some unknown or insufficiently corrected variables in their design.

The often-neglected practical aspect of any malaria control scheme—namely, the consideration of the ratio of the size of the mosquito-breeding area to the size of the toxic area (represented by the total surface of sprayed walls and ceilings)—has led to some disappointments. In one case at least (in the Gambia) this was recognized at an early date and recommendations were made accordingly, substituting a plan for swamp drainage in preference to a residual control of a small area by insecticides.

It seems that in some parts of Africa too much reliance has been placed on the possibilities opened up by the residual insecticides. This has led to their uncritical or perhaps inexperienced use, and was often accompanied by a neglect of simple laws of environmental sanitation or by a rejection of the time-honoured, cheap, and logical methods of prevention of mosquito-breeding.

The results obtained in Ilaro (Nigeria) have shown clearly that the success of a malaria-control scheme by residual insecticides depends in Africa, as elsewhere (Gabaldon, 1953), on the size of the controlled area. It is possible to decrease but not to eliminate the malaria transmission from a relatively small area surrounded by a vast uncontrolled territory. Two factors will constantly upset the results: the influx of infected mosquitoes from the outside and the usually underestimated mobility of the indigenous population, liable to acquire new infections when leaving temporarily the narrow limits of the controlled area.

The discovery of the irritant effect of D.D.T., the knowledge of the relationship between its particle size and the toxicity to mosquitoes, the crystallization effect from oil solutions, the absorptive and chemical effect of some mud

surfaces, the fumigant and particulate effect, the importance of susceptibility of water-dispersible powders, the nature and proportion of the diluent, the effect of tropical storage, and many technical aspects of the spraying routine such as blockage and erosion of nozzles, uniformity of coverage, ratio of absorbent to non-absorbent components of the wall surface, etc., all these slowly emerging factors have not ceased to emphasize the fact that residual spraying needs a careful planning, thorough execution, and constant supervision—postulates not easy to follow in tropical Africa with its chronic shortage of trained personnel.

Reports on some large malaria-control schemes in Africa were somehow conflicting. D.D.T. was claimed to have been very successful in the Belgian Congo, Ruanda-Urundi, Transvaal, Mauritius, and Reunion, less satisfactory in Swaziland, and disappointing in Uganda (Kasanje).

The arrival of B.H.C., with its high initial toxicity at very low dosage, its relative lack of irritant effects on the mosquito, the absence of the factor of critical particle size, and, last but not least, its low cost, aroused great hopes and seemed to point to it as the ideal insecticide for malaria control in tropical Africa. In most of the schemes in which B.H.C. was used (particularly in Southern Rhodesia, according to Alves and Blair (1953), and partly in Nigeria) it gave good results, but it was found unsuitable in Mauritius.

During the last two years evidence began to accumulate that, applied at the initially advocated low dosage of 0.11 g. gamma isomer per m.² B.H.C. has a satisfactory residual effect shorter than the expected three months, and there is now in tropical Africa a growing tendency to use much higher doses, up to 0.4 g. gamma isomer per m.² (Alves and Blair, 1953) to prolong the duration of the residual action.

"Dieldrin"—the latest arrival on the field of residual insecticides—is extremely promising because of its high initial and long residual toxicity to mosquitoes even at a very low dosage, because of its effect on culicines as well as on anopheles, and because of the economy in its use. Its higher toxicity to man and his animals might be less important than expected, and does not prevent its use on a large scale, as shown in Venezuela. It is possible that dieldrin will prove to be the most suitable insecticide for tropical Africa.

Long Residual Action

The object of malaria control by residual insecticides is to create artificial conditions in which the reproduction rate of malaria is consistently kept below 1.0 (Macdonald, 1952). In rural areas of tropical Africa the density of *A. gambiae* is often so high that even when the man-biting index is below the conventional figure of 0.5 the reproduction rate of the disease cannot be maintained at its target figure below 1.0 unless the persistent anopheles mortality is at least 70% (Macdonald and Davidson, 1953). Thus for the purpose of malaria control in these areas a steady level of toxicity of sprayed indoor surfaces is more important than a short high initial kill. An insecticide combining a small effective dosage with a long residual action is particularly necessary in rural tropical Africa with its low population density, shortage of trained labour, and poor communications.

The advantages of an insecticide with a long residual action lies not only in its saving of costs of labour and transport. Problems of malaria control in underdeveloped areas have their ethnological and sociological implications, which must not be forgotten. In the almost mediaeval, closed, Moslem societies of West and Central Africa, with their strict customs, seclusion of women, and distrust of strangers, any invasion of the privacy of the compound is resented and will be tolerated only when absolutely necessary. Here again if we want to preserve the good will and gain the co-operation of the local people the residual spraying must be restricted to one or at most two cycles per annum.

Resistance of mosquitoes to insecticides, reported from other parts of the world, has not been recorded from tropical Africa, where attempts at control by contact insecticides have been few. Nevertheless, the possibility of its happening must not be overlooked, and it can safely be predicted that should it ever happen it would concern *A. gambiae*. The use of a highly toxic insecticide with a long residual action is less likely to produce any resistant strains.

4. Economic Aspects of Malaria Control in Tropical Africa

The problem of costs of malaria control is the leitmotiv of many conflicts not only between the public health officer and the administrator, but also between the malariologist and the public health officer. And it is the economic possibility of malaria control within the general framework of medical and health services that presents one of the challenging dilemmas in Africa. In some malaria-control projects carried out in tropical Africa the assessment of costs is often made very casually if reported at all, and the lack of standards for uniform appraisal of costs in widely varying conditions makes any comparisons between them very difficult, to say the least. The new W.H.O. proposals for standard assessment of costs of malaria control will improve the situation considerably.

Calculating the cost of malaria control by residual insecticides from some African projects, and expressing it in a convenient consolidated figure per head of the protected population per annum, we arrive at figures varying between 1s. 6d. (25 U.S.A. cents) and 5s. (70 U.S.A. cents), with a median cost of 3s. (42 U.S.A. cents).

It is interesting to note how the proportion of separate items of the cost of malaria control varies according to the type of the area, type of the insecticide used, number of spraying cycles, labour wages, and transport problems. Averaging the differences and oversimplifying the overall picture, one can say that in a large-scale project in rural African areas the cost of the insecticide constitutes about 30-50% of the total expenditure, the cost of labour and supervision between 25 and 40%, the cost of transport between 10 and 40%, and the cost of spraying apparatus and contingencies between 2 and 5%.

The cost of labour and transport is an important item in any large-scale malaria-control scheme in Africa, and this more than anything else will irresistibly increase the demand for an insecticide with a long residual action. It is in this field particularly that the competition between the relatively cheap B.H.C. and the relatively expensive dieldrin will become acute.

It was of interest to calculate the costs per head per annum of a pilot malaria-control project in Northern Nigeria and assess them separately for three main insecticides (D.D.T., B.H.C., and dieldrin) at generally accepted dosages and spraying cycles.*

Relative Costs

This calculation shows that, taking into account only the insecticide, labour, and supervision, the cost of a D.D.T. project amounts to 3s. per head per annum, the cost of a B.H.C. project to 2s. 3d., and the cost of a dieldrin project to 2s. 4d. (42, 32, and 33 U.S.A. cents respectively). If we add, however, the costs of transport over a large area with primitive roads and the high cost of fuel, lubricants, and repairs, then the differences between the above figures become even more pronounced, and are: 3s. 3d. for D.D.T., 2s. 9d. for B.H.C., and 2s. 7d. for dieldrin (46, 39, and 37 U.S.A. cents respectively).

The above costs of residual spraying of rural areas of tropical Africa are calculated at frequencies of spraying as

*D.D.T. at 2 g. para-para per m.² twice per annum. B.H.C. at 0.15 g. gamma isomer per m.² four times per annum. Dieldrin at 0.25 g. per m.² twice per annum. All as water-dispersible powders, of 50% concentration for D.D.T. and dieldrin, and of 6.5% concentration of B.H.C.

adopted by the Kampala Conference (1951). It is possible or even probable that in parts of tropical Africa, where climatic conditions are sharply seasonal and the malaria transmission period short, a reduction by half of the frequency of spraying might be adequate to intercept the infection.

In that case the total cost of malaria control by residual insecticides might decrease to something between 1s. 4d. and 1s. 9d. a head per annum, equivalent to 21-25 U.S.A. cents. This is the lowest possible cost of adequate malaria control in semi-rural or rural areas of tropical Africa, in the present circumstances, and with the barest amount of supervision.

The sum of 1s. 4d. to 1s. 9d. (21-25 U.S.A. cents), readily acceptable in many parts of the world and perhaps also in some more developed parts of Africa, is, however, seen in a different perspective when one recalls that over most of tropical Africa the total expenditure on all medical and health services amounts to something between 1s. 6d. and 3s. (21-42 U.S.A. cents) a head per annum.

It is here that the malariologist comes to an argument with the medical administrator and the medical officer of health. How can we hope to extend malaria control over wide rural African areas if our lowest estimates of costs represent in the best case 50%, and in the worst case 120% of the total medical and health budget per head?

Administrative Point of View

We know that in the African tropics malaria is an insidious, ever-present enemy, killing infants and young children, sapping the energy and strength of the people, interfering with education; decreasing the labour output, and preventing or slowing down the economic development. And yet, because of the absence of epidemic malaria, this steady wastage of life and human assets is not dramatic. The medical administrator who has to balance his financial estimates between general hospital care, sanitation, malnutrition, and such spectacular social diseases as leprosy, sleeping sickness, yaws, tuberculosis, smallpox, schistosomiasis, yellow fever, and so on, has often little patience with our, to him, one-sided and expensive argument.

From another point of view malaria-control schemes find little favour with the administrative authorities. Unlike a vaccination campaign or the checking of an outbreak of cerebrospinal meningitis, a malaria-control project is a long commitment without a prospect of rapid and dramatic result even if it is successful. In the latter case, as pointed out by Covell (1953), it is often difficult to maintain the control, because the administration is reluctant to provide further funds when malaria is no longer serious for the community.

It seems that at the present time an efficient country-wide malaria-control programme can hardly be undertaken and be integrated into the general framework of public health services in underdeveloped areas in tropical Africa. This does not mean, however, that we must wait patiently for some future changes in economic conditions. On the contrary, we must make every possible effort to start and to carry out malaria control pilot schemes in varying environmental conditions and using different methods. These projects when properly supervised, assessed, and reported will produce series of basic data which, when interchanged between different African territories, will bring us much closer to the ultimate solution of the problem of expanding malaria control as efficiently and as economically as possible, and of fitting it permanently into the standard public health activities in tropical Africa.

The need for such projects is vital, and the fact that no fewer than five of them (in Liberia, French West and Equatorial Africa, British East and West Africa) are already in their early stage and that they have the active co-operation and help of such powerful bodies as W.H.O. and Unicef is a good augury for the future.

5. Sociological Environment in Tropical Africa

The problem of uncontrollable population pressure is often quoted as an argument against the "premature promotion of malaria control in tropical Africa." The example of the Far East has shown that large-scale public health programmes improve human welfare in an immediate sense, but may defeat their own aim by leading to a rapid growth of population, which more than offsets the benefits that might otherwise have been enjoyed by a steady improvement in economic conditions. How does this situation, so well studied in the Far East and giving rise to so much concern, apply to tropical Africa, with its inherently high reproductive potential?

The population of tropical Africa—estimated in 1935–6 at 96 million (Hailey, 1938)—is estimated to-day at about 150 millions, with an average density of 17 per square mile. Such average figures are apt to be misleading, however, since we must exclude from the calculation the land not suited for human occupation. Variations in the average population density of tropical Africa will become apparent when it is realized that area densities of the population are from 1 per square mile in Bechuanaland, through 5 in the Sudan and Northern Rhodesia, 12 in Belgian Congo, 40 in Uganda, Nyasaland, and the Gold Coast, 67 in Sierra Leone and Nigeria, to over 150 per square mile in South-eastern Nigeria and in Ruanda-Urundi. This uneven distribution of the population is due to an uneven distribution of land suitable for continuous human occupation.

The population of tropical Africa, stationary or perhaps even declining during the eighteenth and nineteenth centuries, because of epidemics, wars, and the infamy of the slave trade, is now increasing at a rate on which the demographers cannot quite agree. Notenstein (1949) estimates that the most probable annual rate of the present population increase in tropical Africa is about 1.5%, and that this rate of growth will continue until 1970. Thus within the span of a man's life tropical Africa will double its population if the present rate of growth is maintained.

This may not be entirely due to the imperfect and, until now, only half-hearted methods of improving the health of the population, but it would be reasonable to assume that these methods have contributed a great deal and that they are gathering momentum. The increase of population in Africa is mainly due to an increased rate of survival.

Farming and Population Problems

The greatest part of tropical Africa is favourable to pastoral rather than to agricultural economy, but an enormous proportion of the potential cattle country is infested by the tsetse fly, which makes cattle rearing impossible. Most of the arable land not already in use is marginal and needs a great amount of work, fertilizers, and agricultural pesticides to give reasonable returns. Those who think that modern methods of mechanized agriculture will help in developing marginal lands forget that in Africa much of the unused land is very short of water.

There are possibilities of temporary nature such as improvement of present farming methods by mixed farming and fertilizing with animal manure. Unfortunately such advances have been in many instances offset by deforestation and by the general worsening of soil erosion. A more balanced approach could be achieved only by collective scientific farming instead of the primitive and wasteful small-farming methods. But this needs a heavy capital outlay, skilled technique, and, above all, a revolutionary change of old social traditions of land tenure. This change must be voluntary, since any coercive methods are out of the question from the point of view of the present administrative policy.

There is no agreement among the demographers and social scientists about the actual existence of the problem of

population pressure over tropical Africa. Macmillan (1949) goes so far as saying that "the population of Africa as a whole is positively inadequate. Many hands are needed even to clear the minimum of land at present under cultivation and then to keep it effectively occupied. The people are really all too few." On the other hand, most experienced colonial administrators agree that there is undoubtedly serious overcrowding in many areas and land hunger with all its attendant evils.

At the present time the problem of overpopulation of tropical Africa as a whole is not yet acute, and there is still some margin of safety. But this margin is narrowing every year, more slowly in some parts, faster in other parts, and the stage is set for future problems as difficult as those that mankind is facing now in Asia, if not more so. It is unlikely that in its *present stage of economic development* tropical Africa could withstand any considerable population pressure.

That successful malaria-control projects in Africa may have similar effects on the demographic curve as they have had in India, Ceylon, and British Guiana can be seen from the example of Mauritius and Madagascar, where the infant mortality has decreased spectacularly within the last few years. Small wonder that some people view our efforts with concern and refer to us as "sorcerer's apprentices," unable to control the primeval forces that we might unleash. A rapid improvement of economic conditions is therefore necessary to provide for the growing population and to create all the essentials important for the well-being of modern States.

But the standard of health and education both influences and is influenced by the economic status. African standards of health and education cannot rise unless more wealth can be produced to provide for them; on the other hand, higher standards of health and education are equally necessary to increase economic production, since ill-health and ignorance are powerful factors in keeping people poor. Poor health conditions and backwardness are the main barriers to an economic development based on the increased food production *per head* so as to support the growing population with greater efficiency (Batten, 1949). It is my deep conviction that better health and better education are basic conditions for greater receptivity of modern trends in improvement of the economic environment in tropical Africa.

It is true, as Davey (1950) points out, that in countries of the Western Hemisphere diseases were not originally controlled as a result of a sudden medical intervention but by a steady improvement in standards of living, by a process compared to a biological growth, the speed of which depended on the technological level, and above all on the general education and active co-operation of the population. To-day we are trying to reverse this process—a method which has not yet been tested by long-term results, and which, although imposed from without, is generally followed by spectacular immediate successes in bringing down the high morbidity and mortality of underdeveloped areas.

It is clear that an attempt to solve the immensely complicated problem of overpopulation should be made not only in those countries where it already exists but also in those where it is looming in the distance, since in the latter case it may be easier to introduce the stabilizing processes. These stabilizing processes are a balanced and simultaneous development along educational, economic, medical, and social lines, with special attention to raising the status of women, and to a gradual stabilization of the population by birth control. Problems related to voluntary limitation of the size of the family are notoriously difficult to put into practice because of the religious and moral principles involved. But "the social ethic, like the law, is mutable . . . and will have to be adjusted to the circumstances of a world in which the major quest is for social amelioration" (Crew, 1953).

The difficult problem of population growth will never be solved by neglecting public health. And withholding

the resources of modern public health methods, of which malaria control is one of the most brilliant achievements, will certainly not create an environment suitable for a balanced development. As Russell (1952) says: "Pooled intelligence is required, not passive dependence on those capricious forces of nature which indiscriminately sacrifice human lives and cultural institutions."

Discussion

This is the background against which the medical and health policies in tropical Africa should be framed and must be judged. The health situation needs attacking from many angles: prevention of disease, treatment, health education, nutrition, and control of population increase. The difficult point is to decide on the order of priority of these goals, not only in relation to their respective importance but also with regard to the economic possibilities of rural areas which are providers of food and foci of disease.

Seeing that the rapidity of results achieved by modern public health measures and particularly by the control of insect-borne diseases always outstrips other aspects of harmonious socio-economic development, the administrator, the social scientist, and the agricultural officer would like us to keep pace with them, to adjust our methods to their stride, and to take part in a "co-ordinated" programme of development. But experience has already shown that the speed of such a co-ordinated programme will have to be adjusted to the speed of its lowest component. Can we slow down for the sake of keeping in line? Have we any choice?

It seems that, even had we desired it, we cannot impede the march of events for the sake of theoretical considerations: primarily because we have been taught by experience that even for a co-ordinated programme it is a better policy to emphasize at first one or two fields—either health or education, or both. Later, when the first field is established, the comprehensive programme can be developed, and will be speeded up by the example and success of one part of it.

We often hear the argument that a single-purpose project is bound to fail, and examples of such failures are often quoted. But the truth is that nearly all of these failures are due to careless planning. It will be pertinent to outline here the five points of sound planning of any programme of technical aid in underdeveloped areas quoted after Marshall Balfour (1952).

1. Objectives of the plan must be clear and definite, and they should have prospects of realization.
2. The personnel needed for it must be competent, qualified, and, above all, available.
3. The environment of the plan must be favourable for its realization. In other words, a need for the plan must be either felt by the population concerned or it must be created.
4. Sufficient time must be allowed for the job and there must not be too much pressure for immediate results.
5. There must be adequate funds to carry out the plan, remembering that long-term projects have considerable financial implications.

The other reason why we cannot possibly slow down the progress of modern public health to keep it in line with the gradual development of all spheres of social and economic activity is the demand for faster improvement of health standards in tropical Africa. This demand comes primarily from the growing national political movement, which desires the African (and quite rightly so) to have his share in the progress of mankind.

Intelligent nationalism can be a strong unifying factor wherever the people are not unified on the basis of common culture. There is no doubt that the days of crude colonialism have gone, and the new national political trends are most obvious in British West Africa, where the idea of trusteeship has originated and where no attempt has been made to suppress the indigenous culture or to model it according to some pattern. However, there are forms of extreme

and destructive nationalism which create a distrust and antagonism towards all things that are foreign, and which will jeopardize any honest attempt to help the underdeveloped areas. To prevent these extreme forms of nationalism, and to create the collective African effort which will be the basis for social and economic development, we must have genuine African leaders on our side. And so we come back in a circle to politics again in its widest application.

As Huxley (1948) says: "There is no problem in tropical Africa that it not part of some other problem. All are intertwined; nothing can be treated in isolation." How, then, to provide adequate medical care and how to control the numerous prevalent communicable diseases over a huge area inhabited by a large and varied African population, the majority of whom are at a low stage of social and economic level, live under unsanitary environmental conditions, suffer from malnutrition, have a very high infant mortality rate, and yet continually increase in numbers? How to make the necessary progress when this population is as yet unable to contribute substantially toward the financing and staffing of a tolerably adequate medical service and has to rely almost entirely on help from the outside? How to extend the social services in spite of the acute shortage of trained staff, and how to minimize the time lag between rapidly growing needs of the people and much slower economic development, hampered at times by the social confusion and political tensions of a culture in an acutely transitional stage? A tall order, indeed!

For centuries the rhythm of Africa remained unchanged. In the enormous, brooding, hot silence of this cruel and beautiful continent, man's activities were moulded by the environment. But, to-day, Africa is different. It is a continent in spasmodic transition, in ominous ferment, launched on an irreversible social revolution, and it would be unthinkable and dangerous to try to withhold from it any fruit of human progress.

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