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AFRICAN CONFERENCE ON BILHARZIASIS

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Report

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AFRICAN CONFERENCE ON BILHARZIASIS

Report

The African Conference on Bilharziasis, convened by the World Health Organization, was held in Brazzaville, French Equatorial Africa, from 26 November to 8 December 1956. Mr J. Cédile, Governor, Secretary-General for French Equatorial Africa, representing Mr Paul Chauvet, High Commissioner of the French Republic, Governor-General for French Equatorial Africa, opened the Conference. He thanked the World Health Organization and the Director of the WHO Regional Office for Africa, Dr F. J. C. Cambournac, for the interest they have shown in African territories and drew attention to the gravity of the disease in agriculturally developing countries. He closed with his best wishes for the success of the Conference and expressed his hope that it would pave the way to the control of the disease.

Replying to Mr Cédile, Dr F. J. C. Cambournac mentioned that this was the first bilharziasis conference to be convened in Africa, and thanked the participants, who had come from Africa, the Pacific, Europe, the Mediterranean area and the United States of America, for attending. He stressed the importance of the disease and its complexity in Africa, underlining the difficulties of control and the necessity for further study. He asked particularly that participants should endeavour to guide public health authorities and administrations in general in their efforts to control the disease.

The Conference then elected Médecin-Colonel R. Beaudiment as Chairman, and Dr W. Alves, Dr D. M. Blair and Dr B. de Meillon as Vice-Chairmen. Dr J. Fraga de Azevedo, Dr J. M. J. Gillet and Dr R. J. Pitchford were appointed Rapporteurs.

The Conference slightly modified the provisional agenda presented.

1. PRESENT DISTRIBUTION OF BILHARZIASIS AND OF EXISTING INTERMEDIATE HOSTS IN AFRICAN TERRITORIES SOUTH OF THE SAHARA

Following the recommendations of the Joint OIHP/WHO Study Group on Bilharziasis in Africa [1] and the first report of the Expert Committee on Bilharziasis [2] a series of surveys was made by WHO consultants from 1950 to 1956, the results of which were submitted to the Conference.[3]

The Conference suggested that maps be produced to show the distribution of the disease, the intermediate hosts and the distribution of animal schistosomiasis. A provisional map showing the distribution of human bilharziasis in Africa was submitted to the Conference. The participants were invited to provide their own complementary information on this subject to the World Health Organization.[4]

1.1 Human bilharziasis

1.1.1 *Schistosoma haematobium*

1.1.1.1 *Western Africa and Guinea coast*

Gambia. The infection is very limited in the western half of the country but is endemic in the eastern half. The area of endemicity continues into the upper reaches of the river Gambia in French territory.

Portuguese Guinea. Foci are restricted to the northern half of the territory.

French West Africa. Distribution is patchy in all territories : Mauritania, Senegal, French Guinea, French Sudan, Ivory Coast, Upper Volta, Niger and Dahomey. The disease is more prevalent in savannah than in forest zones.

Sierra Leone. There is widespread distribution in the higher mountainous regions inland, and the infection is probably imported into the lower-lying tracts parallel to the coastline.

Liberia. The infection is prevalent in the inland portion of the Central Province and the Western Province. It is absent from most parts of the Eastern Province. It does not occur in the coastal area.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1950, **17**

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1953, **65**

[3] Unpublished working document WHO/Bil.Conf./51

[4] An amended version of the map incorporating additional information submitted by the participants at and after the Conference is reproduced in Annex 4 (page 43).

Gold Coast.[1] The disease has patchy distribution in the south but is widespread in the north.

British Togoland. The disease occurs in the Ho area.

Togo. Patchy distribution is found in this territory.

Nigeria. The disease has a patchy distribution in the south, but is widespread in the north.

British Cameroons. The disease occurs in the south, in the neighbourhood of the crater lakes, and in the north. It is apparently absent from the central districts.

French Cameroons. The disease is endemic in the north but found only sporadically in the south.

It will be noted that in western Africa *S. haematobium* is often rare near the coast and more prevalent in the hinterland.

1.1.1.2 *West central Africa, Congo basin and south-western Africa*

Numerous foci exist in the northern parts of *French Equatorial Africa*, in the whole Chad Territory and in northern and eastern Ubangi-Shari.

The disease is absent from the central Congo basin and, in general, from the dense tropical rain-forest zones. However, new foci have become established in the northern fringes of these zones, in southern Ubangi-Shari, *French Equatorial Africa*, in new plantations at Alindao (Basse-Kotto) and at M'Baiki (Lobaye), as well as in north-western *Belgian Congo*, at Bosobolo (Congo-Ubangi District).

Endemicity then reappears near the southern border of the Middle Congo, *French Equatorial Africa*, with a small focus in the Kouilou region, and continues southwards. The disease is present in the Portuguese enclave of Cabinda (*Angola*), along the river Chiloango, and in one village, Buku-Dundji, across the border, in the Mayumbe region of western *Belgian Congo*. Another unimportant focus exists on Mateba island in the mouth of the river Congo. Somewhat more important foci occur further inland, on both sides of the river.

The disease is found in the entire western half of *Angola* ; the eastern districts of Lunda and Moxico appear to be free of the disease. The region south of Angola to the Cape is free from infection.

In the south-eastern *Belgian Congo*, *S. haematobium* is endemic in that part of the Upper Katanga which projects into Northern Rhodesia and along the river Luapula down to Lake Mweru, as well as along the

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[1] Name changed to Ghana since the Conference met.

river Lualaba down to Kongolo ; it is not found further downstream, at Kasongo, but reappears at Kindu. On the whole, the infection is most prevalent in the south and diminishes towards the north.

1.1.1.3 *Eastern and South Africa*

Kenya. The infection is present in patches near the semi-permanent waterholes in the arid Northern Frontier Province, also at Kitui and at Machakos. It is prevalent on the coast. The infection is also prevalent on the rivers feeding Lake Victoria.

Uganda. The disease is generally common in the east and appears to be spreading westward. *S. haematobium* infections have not been found in the west of the country.

Ruanda-Urundi. The disease is absent.

Tanganyika. The disease is widespread and is found in all provinces.

Zanzibar and Pemba. The infection is very common on these islands.

Northern Rhodesia. The infection is widespread.

Nyasaland. S. haematobium has long been recognized here. The disease is very prevalent especially in the areas below 500 m bordering the western shore of Lake Nyasa and in the Shire valley. It also occurs at higher altitudes on the plateau bordering the Rift valley and in the Shire highlands.

Mozambique. The entire territory is reported as endemic for *S. haematobium.*

Southern Rhodesia. The infection is widespread.

Bechuanaland. Urinary bilharziasis is known only in one locality, Mochudi, in the east of the territory.

Swaziland. This territory is also within the endemic zone.

Basutoland. The infection does not occur.

Union of South Africa. The infection occurs in most of the Transvaal and in the subtropical belt east of the Drakensberg mountains in Natal. Foci have been reported in the east of Cape Province.

Madagascar. The endemicity is restricted to an area along the western coast of the island.

Mauritius. The disease occurs with moderate severity.

1.1.2 *Schistosoma mansoni*

The distribution of *S. mansoni* is more limited than that of *S. haematobium* ; it is usually more patchy and recorded incidence-rates are lower.

At the same time, less information is available with regard to the lighter infections.

South of the Sahara a belt of endemic foci crosses the continent, coinciding more or less with the wet steppe and savannah woodland zones and partly overlapping the distribution zone of *S. haematobium*.

Surveying this belt from west to east, it is found that two foci are known in the Casamance valley, *Senegal*. *S. mansoni* co-exists with *S. haematobium* in the Kabala area in northern *Sierra Leone* and is found in adjoining areas of *French Guinea*. It is known to occur, to a limited extent, in the hinterland of *Liberia*, in several localities of the north-west of Central Province, in the proximity of *French Guinea*.

Numerous foci are reported in the *French Sudan*. The infection is recorded from *Upper Volta*, north-eastern *Gold Coast*, and northern *Nigeria*.

In the West African regions lying south of the above, and bordering the Gulf of Guinea, a newly-established focus at Abidjan, *Ivory Coast*, has been recorded, as well as other foci in central and southern *Togo* and *Dahomey*.

Apart from the recognized foci, *S. mansoni* is usually described as sporadic throughout west Africa.

The territories south of Lake Chad are infected to a more important degree. *S. mansoni* exists in the south-western and the southern parts of the *Chad*, which are among the most uniformly and heavily infected regions of Africa.

S. mansoni is not prominent in west central Africa. In the southern *French Cameroons* the disease is reported as unimportant. Cases are recorded from Oyem, *Gabon*.

Two definite small foci are known in the western *Belgian Congo*, one at Kimpese and the other at Buku-Bandu, in the Mayumbe.

In *Angola* some cases have been found in Malange, and other cases have recently been described on the eastern frontier and on the border of the Kasai Province (Belgian Congo).

The highly endemic region of *Ubangi-Shari*, where *S. mansoni* is the predominant agent of bilharziasis, continues south-eastwards and eastwards into the north-eastern *Belgian Congo* and into the homogeneous grass and woodland zone of the southern *Sudan* and north-western *Uganda*. In Uganda the disease is well established in the West Nile District, in the Eastern Province, and in certain high-lying lakes in the south-western part of the territory near the Ruanda border.

In the south-eastern *Belgian Congo*, the disease is endemic in most of the Katanga Province, being long established in lower Katanga and more recently in Upper Katanga District; contrary to the incidence pattern of *S. haematobium*, it is lightest in the extreme south. There are also foci of infection along the shores of Lakes Albert, Edward, Kivu and Tanganyika.

The oldest focus in the *Belgian Congo* is probably that of the Lomami-Kasai, further west, where again *S. mansoni* is the only agent of bilharziasis.

In *Kenya*, the infection is important on the eastern shores of Lake Victoria; it is also found in the Fort Hall and Machakos Districts, as well as in Nairobi and neighbourhood, where the altitude is over 2000 m.

In *Tanganyika*, *S. mansoni* prevails on the southern and eastern shores of Lake Victoria and also near Lake Rukwa and Mbeya.

In *Northern Rhodesia*, the infection is almost as widespread as *S. haematobium*, though the incidence is much lower.

In *Nyasaland*, *S. mansoni* infection is very prevalent. This is one of the few regions in Africa where it is in excess of *S. haematobium*, for example at Karonga, in the north, and at Port Herald, in the south.

In *Southern Rhodesia*, infections with *S. mansoni* are common, but usually not as common as those with *S. haematobium*.

In *Mozambique*, *S. mansoni* is widely distributed, but more patchy than *S. haematobium* and less prevalent. It is not known to occur in the Cabo Delgado District.

The infection exists in *Swaziland* but not in *Basutoland* or *Bechuanaland*.

In the *Union of South Africa*, an important endemic area is reported in the eastern Transvaal low-veld; the disease also occurs in Natal.

In *Madagascar*, the endemic region is in the east and south-east of the island.

The disease is absent from *Mauritius*.

1.1.3 *Schistosoma intercalatum*

The areas in which *S. intercalatum* occurs lie in the higher rainfall and tropical forest zones of the *Congo basin* (rivers Lualaba, Congo) and in the region of the lower Ogowe.

S. intercalatum and *S. haematobium* were found together in at least one place, namely Kindu, which is the southernmost focus for *S. intercalatum* and the northernmost focus for *S. haematobium*. Heavy urinary infections with *S. intercalatum* have been seen, although they are extremely rare.

S. intercalatum occurs mainly among fishing tribes, such as the Wagenia and Lokele of the Congo region and the Pahouin or Fang of the Ogowe, and is apparent mostly among the young.

Eggs morphologically similar to those of *S. intercalatum*, have been found in persons from *Nigeria* and the *French Cameroons*.

1.2 Intermediate hosts

The Conference was glad to have the help of the malacologists present, who prepared the following provisional lists of intermediate and potential intermediate hosts of human bilharziasis and animal schistosomiasis.

DISTRIBUTION OF THE SPECIES AND SUBSPECIES OF *BIOMPHALARIA* AND *BULINUS*

The following lists of countries and areas where the various species are to be found cover the localities known to the members of the working party of malacologists, and are in no way exclusive.

All African *Biomphalaria* so far tested or examined have been found to be susceptible to infection with *S. mansoni*. Some, however, have not yet been tested with local strains, and the Conference was of the opinion that such tests should be carried out as soon as adequate facilities are available.

Biomphalaria Preston

1. *B. pfeifferi pfeifferi* (Krauss)
   Union of South Africa, Swaziland, Bechuanaland, Southern Rhodesia, Northern Rhodesia, Nyasaland, Mozambique, Madagascar
   Intermediate host.

2. *B. pfeifferi bridouxiana* (Bourguignat)
   Belgian Congo (southern), Tanganyika (southern), Northern Rhodesia (Northern Province)
   Intermediate host of *S. mansoni* and *S. rodhaini*.

3. *B. pfeifferi rhodesiensis* Mandahl-Barth
   Northern Rhodesia, Nyasaland (Northern Province)
   Intermediate host.

4. *B. pfeifferi nairobiensis* (Dautzenberg)
   Kenya, Tanganyika, Belgian Congo (eastern)
   Intermediate host.

5. *B. pfeifferi rüppellii* (Dunker)
   Eritrea, Ethiopia, Kenya, Uganda, Belgian Congo
   Intermediate host.

6. *B. pfeifferi gaudi* (Ranson)
   Senegal, Gambia, Liberia, Gold Coast, Nigeria
   Intermediate host.

7. *B. germaini* (Ranson)
   French Sahara
   Status as intermediate host not known.

8. *B. choanomphala choanomphala* (Martens)
   Lake Victoria, Lake Kyoga, Victoria Nile
   Intermediate host.

9. *B. choanomphala elegans* (Mandahl-Barth)
   Uganda (Lake Albert)
   Probably intermediate host on experimental evidence.

10. *B. smithi* Preston
    Lake Edward
    Probably intermediate host on experimental evidence.

11. *B. stanleyi* (Smith)
    Lake Albert
    Probably intermediate host on experimental evidence.

12. *B. alexandrina alexandrina* (Ehrenberg)
    Egypt
    Intermediate host.

13. *B. alexandrina wansoni* Mandahl-Barth
    French Equatorial Africa (Ubangi-Shari), Belgian Congo (northern)
    Probably intermediate host.

14. *B. angulosa* Mandahl-Barth
    Union of South Africa (Natal, Transvaal), Northern Rhodesia, Nyasaland, Tanganyika
    Intermediate host.

15. *B. camerunensis camerunensis* (Boettger)
    British Cameroons
    Status as intermediate host not known.

16. *B. camerunensis manzadica* Mandahl-Barth

Lower parts of Belgian Congo
Status as intermediate host not known.

17. *B. sudanica sudanica* (Martens)

Sudan, French Equatorial Africa, Belgian Congo, Uganda, Kenya, Tanganyika
Intermediate host.

18. *B. sudanica tanganyicensis* (Smith)

Belgian Congo, Tanganyika
Intermediate host of *S. mansoni* and *S. rodhaini*.

Bulinus Müller

1. *B. (Ph.) africanus africanus* (Krauss)

Union of South Africa, Southern Rhodesia, Northern Rhodesia, Nyasaland, Mozambique
Intermediate host of *S. haematobium*, *S. mattheei*, *S. leiperi* and *S. intercalatum*.

2. *B. (Ph.) africanus ovoideus* (Bourguignat)

Belgian Congo (eastern), Uganda, Kenya, Tanganyika
Probably intermediate host of *S. haematobium*.

3. *B. (Ph.) abyssinicus* (Martens)

Ethiopia, Somalia
Probably intermediate host, on epidemiological grounds, of *S. haematobium*.

4. *B. (Ph.) nasutus* (Martens)

Uganda, Kenya, Tanganyika
Intermediate host of *S. haematobium* and *S. bovis*.

5. *B. (Ph.) ugandae* (Mandahl-Barth)

Uganda, Kenya
Could not be infected experimentally by one worker.

6. *B. (Ph.) globosus* (Morelet)

Gambia, Portuguese Guinea, Sierra Leone, Liberia, Gold Coast, Nigeria, Belgian Congo, Angola, Union of South Africa (northern), Southern Rhodesia, Northern Rhodesia, Nyasaland, Mozambique, Tanganyika, Kenya, Uganda

Intermediate host of *S. haematobium*, *S. mattheei*, *S. leiperi* and *S. intercalatum*.

7. *B. (Ph.) jousseaumei* (Dautzenberg)

   Gambia, Senegal, French Sudan
   Intermediate host of *S. haematobium*.

8. *B. (B.) tropicus tropicus* (Krauss)

   Union of South Africa, Southern Rhodesia, Northern Rhodesia, Nyasaland, Mozambique
   Probably not intermediate host of *S. haematobium*.

9. *B. (B.) tropicus angolensis* (Morelet)

   Angola
   Status as intermediate host not known.

10. *B. (B.) tropicus zanzebaricus* (Clessin)

    Belgian Congo (southern), Tanganyika
    Status as intermediate host not known.

11. *B. (B.) tropicus mutandaensis* (Preston)

    Belgian Congo (in crater lakes), Uganda
    Probably not intermediate host of *S. haematobium* or of animal schistosomes.

12. *B. (B.) tropicus alluaudi* (Dautzenberg)

    Kenya
    Probably not intermediate host of *S. haematobium* or of animal schistosomes.

13. *B. (B.) liratus* (Tristram)

    Kenya, Madagascar
    Probably not intermediate host of *S. haematobium* or of animal schistosomes.

14. *B. (B.) sericinus* (Jickeli)

    Ethiopia
    Status as intermediate host not known.

15. *B. (B.) guernei* (Dautzenberg)

    Mauritania, Senegal, Gambia
    Intermediate host of *S. haematobium*, and probably of *S. bovis*.

16. *B. (B.) transversalis* (Martens)

Uganda
Status as intermediate host not known.

17. *B. (B.) truncatus truncatus* (Audouin)

Egypt, Sudan
Intermediate host of *S. haematobium* and *S. bovis.*

18. *B. (B.) truncatus trigonus* (Martens)

Lake Victoria, Victoria Nile
Status as intermediate host not known.

19. *B. (B.) truncatus rohlfsi* (Clessin)

Ivory Coast, Gold Coast, British Cameroons, Lake Chad
Probably intermediate host of *S. haematobium.*

20. *B. (B.) nyassanus* (Smith)

Lake Nyasa
Status as intermediate host not known.

21. *B. (B.) coulboisi* (Bourguignat)

Lakes Tanganyika, Kivu, Edward, Albert, Kyoga and George
Intermediate host of *S. haematobium* on experimental evidence, and probably of *S. bovis.*

22. *B. (B.) camerunenis* Mandahl-Barth

British Cameroons
Status as intermediate host not known.

23. *B. (B.) reticulatus* Mandahl-Barth

Kenya, Tanganyika, Northern Rhodesia, Southern Rhodesia
Status as intermediate host not known.

24. *B. (B.) cernicus* (Morelet)

Mauritius
Intermediate host of *S. haematobium.*

25. *B. (B.) forskalii* (Ehrenberg)

Egypt and several other African territories
Probably intermediate host of *S. haematobium* and of *S. bovis* in certain areas

26. *B. (B.) scalaris* (Dunker)

Angola, Belgian Congo, Uganda, Kenya
Status as intermediate host not known.

27. *B. (B.) senegalensis* Müller

Senegal, Gambia
Intermediate host of *S. haematobium* and *S. bovis* in Gambia and probably certain other areas.

The Conference stressed that further studies in the field of malacology were still desirable and should be actively pursued.

1.3 Animal schistosomiasis

Animal schistosomiasis in Africa is undoubtedly more widespread than bilharziasis in man and is encountered in areas where the human disease does not exist. Eggs resembling those of some of the animal schistosomes have been observed in the urine and/or faeces of man in Union of South Africa, Swaziland, the Rhodesias, Mozambique and Kenya. It is interesting to note that, in the first case of urinary bilharziasis recorded south of the Sahara by Harley (1864), the egg of an animal species, probably *S. mattheei*, was found alongside those of *S. haematobium*.

The species of schistosomes [1] described and recorded from animals in Africa are:

(1) *Schistosoma bovis* Sonsino, 1876—from sheep, cattle, goats and camels in Egypt, Sudan, Tunisia, Morocco, various areas in West Africa, French Equatorial Africa, the Belgian Congo, Uganda, Kenya, Angola, Mozambique, Southern Rhodesia, and the Union of South Africa.

(2) *S. mattheei* Veglia & le Roux, 1929—from sheep, cattle and goats in the Union of South Africa, the Rhodesias and the Belgian Congo. This species has been found also in various antelopes, and eggs very similar to those of this species have been recovered from the liver of a horse in Nigeria.

(3) *S. curassoni* Brumpt, 1931—from cattle in French Equatorial Africa. The validity of this species is doubted by some workers.

(4) *S. rodhaini* Brumpt, 1931—from certain species of rodents and dogs in the Belgian Congo.

[1] There is some doubt as to the validity of the identification of *S. spindalis* var. *africana* Porter, 1926, from man and suspected to be a parasite of stock in the Transvaal and Bechuanaland.

(5) *S. margrebowei* le Roux, 1933—from equines, cattle, sheep and various species of antelope in Northern Rhodesia, and from an antelope in the Belgian Congo.

(6) *S. mansoni* var. *rodentorum* Schwetz, 1951—from certain rodents in the Belgian Congo.

(7) *S. leiperi* le Roux, 1955—from horses, mules, donkeys, zebra, cattle, sheep, goats, various antelopes, African buffalo in Northern Rhodesia and cattle in Bechuanaland.

(8) *Bivitellobilharzia loxodontae* Vogel & Minning, 1940—from elephants in the Belgian Congo.

The normal habitat of the animal schistosomes is in the veins of the alimentary tract, but in heavy infections the urinary bladder may become involved. Males unaccompanied by female worms are the rule in the portal vein, and in cattle male worm infections are very common.

Pathogenicity of schistosomes for animals

Heavy infections in cattle are rarely encountered. Exotic breeds in Africa, because of their habit of standing in water during the hot part of the day, are generally more heavily infected than indigenous breeds. Sheep and goats are sometimes found with heavy infections and show extensive cirrhosis of the liver. It is not believed, however, that bilharziasis in cattle and sheep in itself accounts for serious losses, which are most probably due to the ravages of the other snail-transmitted trematodes. The control of snail vectors is warranted, even in areas where human bilharziasis does not occur, because of these losses.

2. IMPORTANCE OF BILHARZIASIS IN PUBLIC HEALTH

Section 1 has shown that, in the whole of Africa south of the Sahara, there are only a few areas where bilharziasis does not occur.

Although it is clear that there need not be any correlation between its widespread nature and its severity, in many areas where the disease occurs a large percentage of the population is infected, and one of the chief dangers lies in what may happen in countries where the extension or the introduction of irrigation schemes plays a vital part in development. A sharp increase in the number of persons infected has already occurred in one such area of the Belgian Congo, and in the Eastern Transvaal, Union of South Africa.

2.1 The victim of the disease

In considering symptomatology, a distinction must be made between those individuals who undergo one or few exposures, and those who are continually exposed to infection from early life onwards.

Frequently, the first symptoms observed are those described as allergic, or toxic—fever, urticaria, pulmonary involvement, bronchitis, liver congestion and eosinophilia. These signs and symptoms are attributable to the growing parasite.

In endemic regions these symptoms are rare or perhaps not noticed, and infections are not seen until they are well established. In children, in areas where all are exposed to the same intensity of infection, the clinical signs and symptoms do not vary a great deal. However, in adults, social and working conditions determine the degree of infection for each category, and indeed its intensity and gravity; for instance, fishermen and workers on irrigation schemes are likely to be more heavily infected than others.

This situation is characteristic of the disease's endemicity in any given geographical region.

2.2 Morbidity and mortality

In order to determine the influence of this disease on morbidity and mortality rates, investigators must have information based on:

(*a*) statistics of those presenting themselves at dispensaries and polyclinics and complaining of symptoms due to bilharziasis, in relation to the total attendance;

(*b*) hospital statistics showing the number of cases admitted for bilharziasis, and the total number of admissions;

(*c*) the number of deaths occurring among those hospitalized for the disease;

(*d*) laboratory examinations, percentage of positives; and

(*e*) statistics based on the digestion of organs removed at autopsies, or on their histological examination.

The interpretation of these figures is not a simple task, and must also take into account several factors:

(1) The attention given to the disease both by the health authorities and the people themselves.

(2) The attitude of the population to medical facilities; some sick people will avoid doctors or hospitals because they fear a long period of treatment with its attendant restrictions.

(3) The existence of great endemics.

(4) Long distances between the areas where bilharziasis is rife and medical centres; the absence of mobile teams for diagnosis and treatment.

2.2.1 *Signs and symptoms*

Certain signs and symptoms must be taken into consideration when an attempt is made to evaluate the degree of morbidity due to the disease.

2.2.1.1 *Intestinal bilharziasis due to infection with* S. mansoni

Three types of symptom-complex can be noted :

(1) Intestinal symptoms, characterized by bouts of diarrhoea with passage of blood and mucus. In the intervals between these episodes, the patient may complain of nothing more serious than vague intestinal discomfort. (Many subclinical cases may be seen who exhibit little or no diarrhoea. However, it is frequently difficult to be sure how many of these intestinal symptoms are due to bilharzia infection, and how many to other causes.)

(2) Hepatomegaly of varying degrees, accompanied, in advanced cases, by ascites. It has been shown in the Belgian Congo, in a focus of heavy infection, that treatment first reduced and then eliminated this sign. However, it is well recognized that hepatomegaly *per se* can have many causes, e.g., malnutrition, and indeed quite large numbers of cases are seen frequently in areas where intestinal bilharziasis does not occur.

(3) Splenomegaly, which is also seen frequently, is difficult to evaluate in regions where endemic malaria is present.

2.2.1.2 *Urinary bilharziasis due to* S. haematobium

(1) *Signs :* haematuria of all grades, from microscopic to macroscopic.

(2) *General symptoms :* general lassitude; vague abdominal and muscular pains; frequently, pain in the back, digestive upsets, with or without

(3) *Urinary symptoms :* localized bladder and urethral pain; cystitis with frequent pain and pyuria; sometimes, in late cases, oliguria, and, in extreme cases, uraemia and death.

The establishment of a disease range (clinical gradient) based on the above should form an essential part of the epidemiological investigation of the disease. Studies of this type are being conducted at the Bilharziasis Pilot Project in the Philippines.

2.2.2 *Capacity for work*

No *ad hoc* studies were reported on the effect of the disease on the capacity for work of those who are infected. It is possibly fair to say that the symptoms of the disease are well tolerated by the adult African in his natural undisturbed life. However, when he is called upon to perform full-time work involving hard physical labour for six days a week, his symptoms may be exacerbated. It would appear reasonable to assume that an interference with work output takes place, and, in this connexion, it was reported that in Mozambique workers infected with *S. haematobium* lost fewer work-days after treatment than before. The Conference welcomed the information that studies on work capacity have been commenced in the Union of South Africa.

2.3 Methods employed in epidemiological surveys of human bilharziasis

2.3.1 *Census and sampling*

(1) In areas where no reliable census data are available, collection of accurate epidemiological information will necessitate a preliminary census of the population to be surveyed.

(2) In gathering census data, information on physical and social environmental factors should be collected as far as possible.

(3) Population samples examined should be adequate to allow differential observations in the manifold classifications required. They should be age-stratified and proportionately distributed in the different environments—physical and social.

(4) If a census is not possible, an attempt should be made to examine individuals belonging to all age-groups.

(5) In interpreting results of surveys, due consideration should be given to the time and place of examination.

(6) In expressing bilharziasis infection rates obtained during surveys, the term *prevalence* should be used to avoid confusion with the *incidence* of the infection, the latter term being reserved for the number of new infections occurring during a year, usually expressed per 100 of the population exposed to the infection.

2.3.2 *Immunological methods*

The results obtained in Southern Rhodesia, Brazil and other countries in the diagnosis of bilharziasis by the use of intradermal tests have stimulated interest in this method. Other immunological methods have been tried, for example, precipitin reactions, the cercarial envelope reaction (CHR [1]) and the circum oval reaction, but none of these has yet been employed in epidemiological enquiries.

2.3.2.1 *Types of antigen*

The antigens which have been used in immunological tests for the diagnosis of bilharziasis have been prepared from the following sources:

(1) Eggs and miracidia

(2) Cercariae

(3) Adult worms:

(*a*) homologous

(*b*) heterologous

(*c*) distantly related species.

Extracts of free cercariae and of infected snail-livers have been used for intradermal and complement-fixation reactions.

The adult forms of *S. mansoni* and *S. japonicum* have been the main source of material for the preparation of antigens.

Successful antigens are also prepared from schistosomes of animal origin.

2.3.2.2 *Intradermal reactions*

Positive skin reactions are usually observed in human beings from the fourth week after exposure. In children, however, the intradermal reaction is not as intense as in adults, and a few instances have been reported of infected children who have shown negative reactions. In epidemiological surveys the test will be found positive in a number of persons who are parasitologically negative. A positive intradermal reaction is not necessarily indicative of failure of treatment.

2.3.2.3 *The complement-fixation test*

The complement-fixation reaction is regarded as an accurate and reliable test for revealing possible infection before eggs have been demonstrated. The complement-fixation test, unlike the intradermal test, can be used to study some of the factors involved in group reactions to the antigens prepared from the various trematode species which infect man.

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[1] Vogel's *Cercarian Hüllen Reaktion*

It is recommended that further studies on antigens and their standardization be made wherever possible. Their value in epidemiological surveys especially requires investigation. The exchange of antigens among workers is recommended.

2.3.3 *Pathological methods*

2.3.3.1 *Demonstration of schistosoma eggs in urine and faeces*

Potentially all cases of bilharziasis may be diagnosed on the basis of microscopic demonstration of the eggs as soon as egg production begins. When eggs are numerous in the excreta, no problem in diagnosis is presented; when they are few, concentration techniques must be employed.

Concentration of eggs present in the urine is a very simple procedure. Studies in Southern Rhodesia have shown that the elimination of eggs in the urine is accelerated by hard exercise or work. The patient, after hard exercise, passes the specimen directly into a bottle and sedimentation is allowed to take place for at least 10 minutes. Workers in the Congo and Rhodesia prefer centrifugation. After the supernate is decanted, some of the sediment is placed on a microscope slide and examined. On the other hand, the complete sediment may be placed in a Petri dish and examined with a stereoscopic microscope, a technique which has been used with success in Mozambique and the Union of South Africa.

When an active intestinal bilharziasis infection is present, it is usually possible to recover the eggs from flecks of blood and mucus attached to the outside of the faeces or in undisguisedly dysenteric or mucoid stools. Only direct films, preferably mounted with a cover-glass, are needed for detection of these eggs.

In cases of light infection without accompanying dysentery or diarrhoea, the eggs are incorporated in small numbers in formed faeces. Likewise, in late chronic cases, eggs in any considerable number may be found only sporadically in the intestinal evacuations. These cases call for concentration methods. Very good concentration is accomplished with the HCl-Na_2SO_4-Triton-ether technique; but ether is expensive and difficult to transport and keep. This method is therefore not a practical one for mass diagnosis under field conditions.

The most dependable technique for concentration of schistosoma eggs present in small numbers in the stool is simple sedimentation, employing 0.5% glycerinated water as the diluent. Urinalysis glasses are employed as in vesical bilharziasis and a minimum of 10 g of stool may be sedimented at one time for at least 30 minutes. Stool specimens may be collected in the field in wax pasteboard containers and transported to the laboratory for examination. If the laboratory is provided with an electric centrifuge equipped with buckets for 50-ml tubes, centrifugal sedimentation will hasten the process. Examination of the faeces sediment in a Petri dish by means of a stereoscopic microscope has given excellent results in Mozambique and the Union of South Africa.

Careful weighing of the advantages and disadvantages of the several methods available for concentration of schistosoma eggs from the stool warrants the conclusion that the most practical method for mass diagnosis is sedimentation.

The MIFC (merthiolate, iodine, formaldehyde concentration) technique has been found to be equally efficacious and useful, since the reagent is a preservative. It has proved a reliable test in epidemiological surveys for *S. japonicum* in the Philippines, and has also been used in Egypt in *S. mansoni* investigations.

Hatching technique. Eggs which contain living and hatchable miracidia can be detected solely with the aid of a hand-lens after adding water to the lightly centrifugalized deposit or sediment from the specimen of urine or faeces. Such miracidia hatch quickly, usually within 5 or 10 minutes in the case of urine and 30 minutes or longer in faeces. The water used for dilution should be free from added chemical agents and contain no free-swimming infusoria which might be confused with the miracidia of schistosoma. This is best ensured by heating the water before use to a temperature of 60°C, and allowing it to cool.

The advantages of this method of diagnosis are that the equipment is very cheap and staff is quickly trained. All eggs in a deposit are given an opportunity to hatch out miracidia so that the diagnosis of very light infections is possible. The method is of particular value as a test of cure after treatment.

2.3.3.2 *Biopsy techniques*

Proctoscopic biopsy in suspected cases of bilharziasis considerably increases the number of positive diagnoses made by examination of the excreta.

Terminal-spined eggs of *S. haematobium* or related species can often be detected in rectal biopsy snips even when none can be found by examining a specimen of urine.

Advantages

(1) Both *S. haematobium* and *S. mansoni* can be diagnosed in the same specimen and at greater speed than by examination of stools and urine.

(2) Fresh biopsy specimens can be used to detect viability of the eggs of *S. mansoni*.

(3) The method is inexpensive.

Disadvantages

(1) The method is difficult to employ with children below seven years.

(2) In most instances where *S. haematobium* eggs are found, they appear to be non-viable.

(3) Some populations may object to proctoscopy and this presents certain difficulties in an epidemiological survey.

Epidemiological surveys using rectal biopsy have been carried out in Union of South Africa and Venezuela.

2.3.3.3 *Summary of recommended procedures*

The following practical procedures are recommended for the recovery of schistosoma eggs for the diagnosis of bilharziasis:

1. Eggs passed in the urine accumulate in the sediment at the bottom of a suitable container. This is a simple concentration technique adapted to mass diagnosis.

2. In active cases of intestinal bilharziasis, eggs may be found in flecks of blood and mucus on the outside of formed faeces or in undisguisedly dysenteric stools; direct film examination will usually reveal the eggs amongst the cellular and mucus components of the exudate.

3. In formed faeces it is frequently necessary to concentrate the eggs.

(*a*) Although excellent concentration is effected by the HCl-Na_2SO_4-Triton-ether technique, this method has disadvantages under field conditions.

(*b*) Sedimentation in 0.5% glycerinated water is simple, produces effective concentration, and, since 10 g or more of the stool specimen are processed, it may ordinarily be depended on as an adequate sampling of the stool. It is well adapted for mass diagnosis and use in the field.

(*c*) The MIFC technique has proved useful in the field.

4. Biopsy is particularly helpful in providing a check on sedimented specimens of stool and urine. Although it has been used in field surveys in some areas, it is not generally recommended for this purpose.

5. Hatching of miracidia from sedimented concentrates of *Schistosoma* eggs in water is valuable as a public health measure in providing an

index of the percentage of viable eggs evacuated by schistosome-infected patients.

2.4 Re-infection, receptivity and resistance to infection

Animal experiments have demonstrated that infections of monkeys and small rodents can give rise to partial or complete resistance provided a certain length of time is allowed to elapse before challenging infections are attempted.

Knowledge of similar resistance in man is still very scanty, but epidemiological evidence suggests that superinfection may be resisted when second and subsequent moderate exposures to infection take place after sufficient time has elapsed for a degree of immunity to develop. People who have acquired such resistance can face, it would appear, repeated opportunities for additional infection without the exacerbation of the clinical symptoms which would be expected to result from the additional worm-load. However, persons who are subjected to heavy and repeated infections may be seriously affected before any immunity or resistance is developed, and it may well be also that a sufficiently heavy cercarial invasion will break down any resistance barrier. When such invasions are overwhelming, the resulting degree of infection may build up to a point where the disease is fatal.

2.5 Connexion between diet and pathogenicity in bilharziasis

No evidence was advanced that the parasitization of human beings is affected by diet. There was however some evidence from the Belgian Congo to confirm that the severity of the symptoms in infected persons is mitigated when they are put on an adequate and well-balanced diet. The Conference heard with interest some as yet unpublished work on the infection of mice with *S. mansoni*. Mice fed on a diet deficient in cystine, vitamin E and other factors harboured a much higher percentage of worms than mice fed on a normal diet and exposed to the same degree of infection. It was further noticed that the worms in the mice on a deficient diet showed marked somatic under-development and did not reach sexual maturity. None of the few eggs produced penetrated the tissues, and thus the characteristic pathology did not ensue.

The Conference felt that both aspects of the subject—the effect of deficient nutrition on penetration and development of the parasite and its effect on the maturity and egg-production capacity of the worms—should be further studied in animals and, if possible, in human beings, because of their important bearing on epidemiological studies and clinical aspects of the disease in man.

2.6 Associated psychological disturbances

The Conference was not convinced that there was evidence of psychological disturbances directly attributable to bilharziasis in persons who had contracted the disease at an early age.

When, however, persons acquire the disease at a later age, which is generally the case with Europeans who contract it in epidemic areas, there is evidence that its onset may interfere with scholastic ability, powers of mental concentration, and social behaviour. These effects can be reversed by specific treatment of the infection.

2.7 Carcinogenic action of human schistosomes

After a review of the published data on the subject, it was agreed that there is no valid evidence of a relationship between *S. haematobium* infection and cancer of the urinary bladder in Africa south of the Sahara.

Primary cancer of the liver is stated to be a relatively common condition, but there would seem as yet to be no evidence that this condition is directly associated with human bilharziasis.

3. FACTORS INFLUENCING THE EPIDEMIOLOGY OF BILHARZIASIS

3.1 Intermediate-host—parasite complex

Under natural conditions in Africa, a variety of larval trematodes are present in snails. In the present state of knowledge, it is impossible to be sure, for instance, which cercaria of the closely related schistosomes of the *haematobium-bovis-leiperi-mattheei* group is present, or if more than one of that group is represented. Much work has been done in the Belgian Congo and in Germany on the morphology of mammalian cercariae, and on similar problems, and it is suggested that further efforts be made, directed particularly perhaps towards finding methods for differentiating the members of this group in the field, in order to determine more readily:

(*a*) which snails actually act as intermediate hosts; [1]
(*b*) the seasonal incidence of infection;
(*c*) the development of infections under natural conditions.

[1] The term "vector" is frequently used loosely in speaking of a snail in which cercariae are eventually produced following its penetration by trematode miracidia. In the strict sense such a snail is an "intermediate host", not a "vector" that transmits the infective stage of the parasite to the definitive host.

It has been shown experimentally that certain geographical strains of various snails are incapable of acting as intermediate hosts of schistosomes from other localities.[1]

The following examples are given :

(1) *B. (Australorbis) glabratus* is the common intermediate host of *S. mansoni* in South America and the Caribbean. However, when snails of this species from Salvador, Brazil, were exposed to *S. mansoni* cercariae from Puerto Rico, they could not be infected. When snails of the same species from Recife, Brazil, were exposed to *S. mansoni* miracidia from Mozambique, no infection occurred.

(2) There is evidence, as yet not fully confirmed, that a *Bulinus (Physopsis)* snail acts as a host for *S. haematobium* in Kenya. This snail is widespread in the western part of Uganda, throughout an area where no urinary bilharziasis is seen. It cannot be infected experimentally with *S. haematobium* strains from Uganda.

(3) Somewhat similar is the case of *Bulinus (B.) coulboisi*. In the laboratory, snails of this species from Albertville, Belgian Congo, were exposed to schistosomes from Southern Rhodesia and from Egypt ; they could be readily infected by the Egyptian strain, but were refractory to the one from Southern Rhodesia.

(4) Two species of *Bulinus*, namely *B. (Ph.) globusus* and *B. (B.) truncatus*, were found living side by side at Dawa, Gold Coast. The *B. (B.) truncatus*, when tested experimentally, could not be infected with a West African strain of *S. haematobium*, but was receptive to an Egyptian strain. Exactly the opposite results were obtained with the *B. (Ph.) globusus* snails ; they were, in addition, found to be infected in nature when the snails were collected.

(5) Conversely, when *Planorbarius metidjensis*, the intermediate host of *S. haematobium*, in Southern Portugal, was exposed to a strain from Portuguese Guinea, it was very readily infected.

(6) Schistosome hybrids, produced experimentally in the laboratory, appear to produce miracidiae which have greater invasive powers. For example, a hybrid of *S. mansoni*, from Egypt, and *S. rodhaini*, from the Belgian Congo, infected both *B. pfeifferi bridouxiana* from the Belgian Congo, and *B. alexandrina alexandrina* from Egypt, as well as *B. glabratus*. Previous attempts to infect the Egyptian snail with *S. rodhaini* had failed, as had attempts to infect *B. glabratus* with the Egyptian parasite.

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[1] When a snail can be infected in the laboratory, it will probably be capable of acting as an intermediate host in the field. Failure to infect a snail in the laboratory does not by any means prove that it cannot act as a host in the field.

It was suggested that more research on the physiology of the snails was urgently required, and the earlier suggestion made to that effect in the first report of the WHO Expert Committee on Bilharziasis [1] was strongly endorsed.

Annex 3 (page 42) gives a list of snails prepared by a participant in the Conference, indicating their susceptibility to various strains of schistosomes. This information will be published by him in due course.

3.2 Animal reservoirs

If animals serve as reservoir hosts, their relative importance in human infections should be assessed. Special epidemiological studies of man, and of animal definitive hosts, in the Philippines, have shown that man is responsible for 75% of the miracidia production in this area, and that the remaining 25% is shared among many animals, the most important being the cow, the pig and the dog.

In certain areas of the Belgian Congo, *S. mansoni* infections of man are widespread (50%). In these areas light infections have been found in a small percentage (5%) of wild rodents. Naturally infected small mammals have also been found in Brazil.

In the Belgian Congo and in the Union of South Africa, many species of wild rodents have been infected with *S. mansoni* in the laboratory. Natural infections have not yet been described from South Africa, but the number of animals examined so far has been small.

At present, there does not seem to be great danger, in Africa, from susceptible rodents, but the situation should be carefully studied and a wider range of animals, particularly those which frequent water, should be examined for the disease.

3.3 Influence of human concentration

In areas where there is a combination of population concentration and favourable conditions for undue multiplication of snails, contact between man and the intermediate host is greatly increased. This in turn leads to an increase in the number of infections, and perhaps to a graver symptomatology, as has been seen from the evidence presented in section 2.1 (page 16).

However, it has been found from field studies in the Transvaal, Union of South Africa, that *S. haematobium* and *S. mansoni* have different epidemiologies in this respect. These field studies indicate that in *closely*

[1] *Wld Hlth Org. techn. Rep. Ser.*, 1953, **65**, 23 (section 3.1.5.1)

settled communities, with limited water supplies, pollution of water with both stool and urine is high.

In *more scattered communities*, the limited water available is still heavily polluted with urine, through such activities as swimming, bathing and the washing of clothes. On the other hand, most faecal deposition takes place away from the water, in the bush, and infection of snails with *S. mansoni* is consequently at a lower level, with a naturally reduced rate of human infection.

The number of *S. mansoni* infections will therefore be in direct proportion to population concentration and proximity to water, as already noted. On the other hand, with *S. haematobium*, similar rates in both concentrated and scattered populations are found, since the water-supply suffers almost equal pollution in each case.

There is a danger of dissemination of the disease by movements of populations, and by migrant labour.

3.4 Extension of irrigation operations

It has been shown, in the Belgian Congo, that many cases of *S. mansoni* have occurred after the extension of rice irrigation schemes. As an example, an infection rate of 3-4% was observed in one area. Some 12 months later, the rate had increased to 30-35% and many of the new cases were more severe.

This serves to confirm the fear that the wide extension of water conservation and irrigation projects must pose a new problem in bilharziasis control, and that there is grave danger not only that the number of people infected will increase, but that the infections themselves will become even more deleterious to health and productive capacity.

It was also suggested that the small " market-garden " type of irrigation scheme might be more dangerous than large-scale systems which, in addition to providing better care for water and canals, are likely to have sufficient funds and the possibility of enforcing regulations for proper use and maintenance.

Fish farming is also regarded as dangerous by some workers, since the conditions conducive to successful fish culture may encourage also a rapid and prolific concentration of snails. There is, however, some evidence, also from the Belgian Congo, that at least one species of fish, *Haplochromis mellandi*, is very efficient in reducing and maintaining the snail population at a low level in the confined area of a fish pond.

The Conference considered that the occurrence of large numbers of new aggregations of surface water must inevitably result in a sharp increase in trematode and other worm infections of domestic stock, with a resultant economic and food loss to society.

In the light of these new problems, it was suggested that a meeting between the relevant experts of FAO and WHO be convened with a view to joint action to lessen the dangers inherent in the opening up of Africa.

4. CONTROL METHODS

4.1 Value of molluscicides [1]

Molluscicides have a value in the control of the intermediate hosts of bilharziasis although their use has not often resulted in snail eradication. In situations that demand immediate action, they can be employed with advantage to reduce the number of intermediate hosts substantially and control transmission to a considerable extent until a permanent system for making control measures more effective can be instituted. There are three points that must be considered before a mollusciciding programme can be put into practice :

(1) Does the situation call for snail-population control by the repeated use of molluscicides or should eradication be attempted ?

(2) Is the use of molluscicides economical under the conditions that exist or must it be combined with ecological methods ?

(3) Which compound and what method of application should be used ?

Consideration should be given to the snail ecology, type of terrain, pH, temperature, chemistry of the dissolved solids, aquatic vegetation and streamflow.

The chemicals in common use have been applied in a variety of ways, in powder scattered on the water surface, in bags from which they can soak out for the treatment of larger water surfaces and rivers, in solution by hand-pumps and power-sprayers, in automatic dispensers and, in some instances, in the form of briquettes. Methods of application will vary with the local conditions and be governed to some extent by the aim in view, i.e., whether an immediate killing action is desired or a more prolonged residual effect is needed.[2]

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[1] In this report the word "molluscicide" is used as recommended by the Study Group on the Ecology of Intermediate Snail Hosts of Bilharziasis held in Paris in October 1956 (*Wld Hlth Org. techn. Rep. Ser.*, 1957, **120**, 26, footnote).

[2] It was noted that the Brazilian Ministry of Health, with the co-operation of the National Institutes of Health, Bethesda, Md., USA, was preparing a manual on molluscicide application.

Of the available chemicals that have been screened for their molluscicidal activity, sodium pentachlorophenate and dinitro-*o*-cyclohexylphenol are the most promising. In Africa and America where the intermediate hosts are aquatic, the former appears to be the more effective. Sodium pentachlorophenate is customarily used at 10 p.p.m. (parts per million), and this concentration should be maintained for at least 8 hours. Reports from Venezuela indicate that 5 p.p.m. for 24 hours is effective.

Control of transmission by the spot application of sodium pentachlorophenate has been tried in Brazil in areas along streams where rural populations are sparse and most of the inhabitants are located in villages. When the chemical was applied to breeding areas near the villages, the snails disappeared for six months after which reinfestation of the area by snails from upstream occurred.

In Egypt a pilot control project, using sodium pentachlorophenate in irrigation canals and drains, over an area of approximately 25 km^2, has resulted in a substantial reduction over a period of three years in the prevalence of *S. haematobium* and *S. mansoni* in schoolchildren. No other control measures were utilized. Laboratory studies showing that this compound kills snail eggs were confirmed in this field experiment.

Toxicological studies indicate a lack of toxicity to man and domesticated animals in the dilutions commonly employed. Although the compound is lethal to fish it has been found that it has no long-term effect on fish population, and that their number returns to normal in a short time. It does not appear to affect insect larvae. Sodium pentachlorophenate has also some herbicide effect on certain aquatic plants.

Copper sulfate is one of the three compounds commonly used as a molluscicide. It is well known that copper sulfate combines with organic material in natural waters and that its efficacy is thus reduced. However, further research is needed in order to determine more accurately the distance a known concentration of this compound will flow in natural waters before its molluscicidal properties are diminished or lost. Attempts have been made to achieve treatment with a low continuous concentration of copper sulfate (0.125 p.p.m.) in the Gezira Project of the Sudan. More research on this type of application with other molluscicides is desirable.

Copper sulfate does not seem to be effective in alkaline waters (pH 9.2, Lake Kivu, Belgian Congo).

Sodium pentachlorophenate is a more expensive chemical than copper sulfate, but when used as a molluscicide is cheaper, for the following reasons :

(1) Sodium pentachlorophenate is effective at 10 p.p.m., whereas copper sulfate has to be applied at concentrations ranging from 15 to 30 p.p.m.

(2) Application of sodium pentachlorophenate kills both snails and snail eggs, whereas a second application of copper sulfate is required six weeks following the initial application, in order to kill young snails hatched from the egg clutches.

(3) Original concentrations of sodium pentachlorophenate are maintained in flowing water for long distances (up to about 40 km) in irrigation canals, whereas copper sulfate combines with organic and inorganic material and loses its efficacy within a few hundred metres.

Suggestions for future study

The Conference supported the recommendations made by the Study Group on the Ecology of Intermediate Snail Hosts of Bilharziasis [1] and suggested a few more points for further study:

(1) The effect of molluscicides on the associated fauna and flora of snail habitats; and how the killing of snails and associated animals would interfere with the food chain in the habitat.

(2) Studies on the physiology of snails and the mechanism of action of molluscicides; the utilization of radio-active isotopes for this purpose was suggested.

(3) Studies to determine the efficiency of copper sulfate in maintaining its concentration in solution over long distances in irrigation canals, and the physiochemical factors involved.

(4) The effect of long-term application of molluscicides on crops.

4.2 Value of mass treatment

By mass treatment, in this context, is meant the treatment of the whole of an infected population or an age-group of the infected population. Where the proportion of infected persons is very high, it may mean the treatment of the whole group without individual diagnosis of the disease having been established. In less widely-infected populations, it may mean the treatment of all persons found to be infected.

In Africa south of the Sahara, there have been instances where several thousand patients have been treated in a limited area, for example in the Belgian Congo and Southern Rhodesia, but nowhere has mass treatment been used as a routine control method.

In the Belgian Congo, mass treatment has been applied to persons who were found infected with *S. mansoni* in the course of an earlier survey. Mass survey methods and the treatment of rural populations by means

[1] *Wld Hlth Org. techn. Rep. Ser.*, 1957, **120**, 36

of potassium-antimonyl tartrate were applied in the Kasai focus. Following the treatment, the incidence of the disease (new infections) fell from 8.9% in 1948 to 2.3% in 1951. The same method, applied at Kasenyi, one of the Lake Albert foci, reduced the general infection rate from 69% in 1948 to 38.4% in 1949.

It is particularly interesting to apply mass treatment in foci presenting a considerable number of severe cases. When applied in such foci where reinfection is constant, the method is often without effect on the general infection-rate but reduces the number of serious cases.

In Southern Rhodesia, lucanthone hydrochloride (B.P.) has been used in the mass treatment of populations extensively infected with *S. haematobium*. This drug lends itself to use in mass treatment campaigns as it is given by mouth and is safe. Generally, it has unpleasant side-effects which, however, are least evident in children. It is fairly cheap and has an effective cure-rate. Courses of treatment even shorter and more intensive than the three- to six-day courses which are now usual may assist in reducing the unpleasant side-effects. These occur generally in the latter part of the course and may prevent patients from reporting for a full course of treatment. The efficiency of this drug, however, still needs to be evaluated in all parts of Africa.

In considering the most economic and practical possibilities of mass treatment of urinary bilharziasis, special attention might be given to the treatment of the age-group 6-16 years attending schools. It is believed that the heaviest infection of the intermediate snail host comes from this group of the population.

Mass treatment of the human population, when combined with an attack on the molluscan intermediate host, can be expected to reduce the infection potential considerably.

An account was given of a new drug (antimony dimercaptosuccinate) for treatment of bilharziasis. Further trials of this drug are desirable. The drug has been tried on patients suffering from all three human schistosome infections.

4.3 Parasitological and immunological methods of assessment of cure

There has been wide divergence in the criteria by which results of treatment have been measured, e.g., the time following treatment at which examinations of excreta are made, the number of re-examinations, and the methods employed for examination.

Before criteria for methods of assessment are laid down, the manner in which antibilharzia drugs act on schistosomes in experimental animals must be described, as knowledge of their action is fundamental to the proper assessment of cure.

The effect of drugs on schistosomes in experimental animals has been studied in *S. mansoni* and *S. japonicum* infections. The worms are swept away from the mesenteric veins to the branches of the portal veins in the liver. The worms separate, become smaller, the genital organs atrophy, and the production of eggs ceases. Some or all of the worms die and are slowly absorbed, the process taking 2 to 12 months, which has an important bearing on the employment of immunological methods in the assessment of cure. If some of the worms survive, they may grow again, their genital organs regenerate and egg production may be resumed some weeks or months after treatment. In most cases this does not occur later than 3 or 4 months after treatment.

Experimental work with animals would seem to indicate that eggs laid by the worms have a life of up to 21 days in the tissues, and the indications are that the schistosomicidal drugs do not directly affect the viability of the egg. The experience with animals is borne out by observation during the treatment of human beings.

On this basis it is possible to suggest the following criteria of cure :

(1) If the stool or urine is free of viable eggs after three weeks have elapsed since the last day of treatment, it can be concluded that the drug has had an immediate effect on the worm.

(2) The follow-up period should ideally be as long as possible, but complete cure can only be accepted when repeated examinations have failed to reveal viable eggs for a period of 8 to 10 months. The chief limitation is the difficulty of keeping patients free from the possibility of reinfection for such a long period. In practice, however, it is suggested that a patient who has been treated and is found not to be passing viable eggs for at least 12 weeks after the end of the course of treatment may be considered cured. At least two specimens of excreta per week should be examined. These should be obtained under optimum conditions and examined as soon as possible.

Hatching and other related tests of viability should be used in the assessment of cure. The rupture of the envelope of the egg by pressure on the coverslip or the observance of flame-cell movement may also be used. This movement may also be looked for in rectal biopsy material.

The Conference supported the suggestion that workers using drugs in the treatment of human bilharziasis should state what tests they have used and in what way, in order that some comparisons of cure-rates can be made. The suggestions made in the first report of the Expert Committee on Bilharziasis [1] on examination techniques were supported.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1953, **65**, 40

4.4 Environmental sanitation measures

Sanitation measures should be an integral part of the public health programme and should not be instituted as specific antibilharziasis measures.

In Africa the use of latrines by the rural population is not common and often unknown. This presents a serious problem for which no ready solution is suggested. In urban and closely-settled areas, the provision and use of latrines is an obvious public health requirement. The need for education in the proper use of latrines before starting the programme was stressed, as it has been observed that there is considerable delay before their use becomes general and before any reduction in the infection rates in snails can be expected. Any general programme which includes drainage, filling in of excavations and the prevention of seepages will reduce snail habitats and cause a lowering in the infection potential.

The need for the provision of safe water for drinking, general household use, laundry and swimming was stressed. Any factor which lessens or prevents access of the human population to snail habitats deserves encouragement and support.

The Conference fully supported the sanitation measures recommended by the Study Group on the Ecology of Intermediate Snail Hosts of Bilharziasis.[1]

4.5 Water management

The Conference was in full agreement with the recommendations made on this subject by the Study Group just mentioned.[2]

4.5.1 *Water courses*

Two types of water courses have to be considered: natural water courses and irrigation systems.

Natural water courses vary tremendously in conformation, vegetation and surface-area from place to place, and sometimes within a short distance. There is no ready solution for molluscan control in the case of natural water courses, other than the use of chemicals, and it would appear that, except under special circumstances, education and the protection of water bodies from pollution present the best solution.

In considering the management of irrigation systems, the necessity for careful planning was stressed. Such works should only be undertaken

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1957, **120**, 29

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1957, **120**, 30, 32

after full consultation with health and other interested authorities. When they are properly built, molluscicide application is made easier and the maintenance of snail control is greatly facilitated. When possible, the covering-in of canals should be resorted to.

It was considered that in many irrigation schemes provision is made for the application of too much water, thus leading to seepage and leakage which further encourage snail breeding. Cement or other impervious lining of canals prevents leakage, reduces the vegetation and makes the application of molluscicide easier. The reduction in water-loss also represents an economic gain to the scheme.

Night-storage reservoirs designed to hold irrigation water supplied at night for use on the land on the following day form a particularly suitable habitat for snails, and the use of such reservoirs was strongly condemned. When this storage system cannot be avoided, the reservoirs should be cement-lined.

4.5.2 *Water storage*

Any type of water storage tends to the formation of habitats capable of carrying large snail colonies. Water storage under African conditions generally takes one of two forms:

(1) Small storage dams which impound the water running off a particular catchment area, where no stream or river exists. The volume of water impounded is generally small, and there is no initial snail infestation, but, as the conditions are stable, the snail infestation, once started, rapidly becomes heavy. The irrigation works associated with such a dam are generally small.

(2) Dams across streams and rivers, which impound larger volumes of water. There is an initial snail infestation, which rapidly becomes heavier with the more stabilized conditions and with continued reinfestation from the river. Associated irrigation works are generally larger than in the case of catchment storage dams. Very large reservoirs of this kind do not carry a snail population proportional to the volume of water impounded.

4.6 Health education methods

Health education and general improvement of the social, economic and educational status of the population can be expected in time to improve public awareness of the dangers of bilharziasis and the means of avoiding the disease. It was agreed that health education on bilharziasis should not be treated as a separate subject but should be included within the general programme of health education. Such a programme of education would encourage the people to provide for themselves a purer water supply, latrines, baths and laundries, and these should in turn protect the population from bilharziasis.

In Brazil health education on the dangers of bilharziasis is organized within the framework of the anti-bilharziasis campaign.

When new health education techniques are evolved, which would be applicable in African conditions, careful consideration should be given to their application in bilharziasis control. This, however, is a very long-term objective. The advice to avoid contact with water is hardly practical when agricultural activities have to be pursued and surface water is the only source of supply for drinking, washing, laundering and the recreation of the population.

It is suggested, therefore, that a special effort be made on one point only : a campaign to impress on the population the importance of water to a rural community, and the necessity of avoiding its pollution. A concentrated effort directed towards this link in the chain of infection—namely, the infection of snails by man—may reduce the infection potential sooner than a general health education campaign.

Research is required on methods of overcoming the difficulties at present experienced in conveying advanced ideas on health education to populations of low educational standard.

4.7 Need for collaboration between health authorities and the governmental and private agencies concerned in the study and execution of control measures

The control of bilharziasis in an area goes far beyond the medical and public health field, and further advances will depend to a great extent on the degree to which the interest of departments of agriculture, fisheries, irrigation and public works, in fact the whole administration of the area in general, is stirred by the problem.

The value of the collaboration of private interests and groups should also be realized and every encouragement given to such groups to direct co-operative efforts aimed at snail control and the reduction of the possibilities of contact of the human population with infected habitats. Self-help should be encouraged as much as possible by the governments concerned, by providing technical advice and arranging for the supply of molluscicides at the most favourable prices.

In each area the health administration should bring to the notice of government departments, and big farming and industrial enterprises, the facts concerning the incidence and prevalence of bilharziasis and advice on the best methods of combating it. In this way, the interest of those in the best position to carry out improvements will be encouraged.

5. INTERNATIONAL CO-ORDINATION OF BILHARZIASIS CONTROL AND RESEARCH ; EXCHANGE OF INFORMATION ; TRAINING OF PERSONNEL

The Conference expressed its appreciation of the programmes already executed or being planned by WHO, which include assistance in the implementation of pilot projects by governments.

With a view to establishing a clear classification of molluscs for practical use in the field, WHO has co-ordinated the work of the snail identification centres.

The shortage of qualified personnel for epidemiological surveys was deplored by the Conference. This shortage, as well as the advisability of further studies, has however been taken into consideration in the award of fellowships and the exchange of consultants. The Conference recommended that a training course be held in the near future for medical officers in charge of bilharziasis control, civil and sanitary engineers, biologists and parasitologists dealing with problems of parasites and intermediate hosts.

The Conference also noted with approval the suggestion for a field research team made by the Study Group on the Ecology of Intermediate Snail Hosts of Bilharziasis.[1]

In giving its collaboration to the implementation of a programme in a given region, WHO takes care not to interfere in any way and to adhere to its advisory role. This attitude was particularly appreciated by the Conference, which invited WHO to continue its efforts and to encourage surveys in the field for the purpose of obtaining comparable data, scientifically based, on :

(1) the evaluation of the gravity of bilharziasis in Africa ;

(2) the basic information essential to bilharziasis control ;

(3) the scientific value, effectiveness and disadvantages of new chemotherapeutic preparations and new molluscicides.

The Conference also suggested to WHO that it consider increasing the dissemination of new information on the disease.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1957, **120**, 36

The Conference, impressed by the importance and gravity of the extension of snail-borne diseases in domestic stock—an extension likely to follow the probable developments already discussed—, invited WHO and FAO to collaborate in seeking measures to prevent the losses in food production which would otherwise be inevitable.

The Conference expressed the wish that exchange of information and close co-operation be established between WHO and the Commission for Technical Co-operation in Africa South of the Sahara (CCTA) in the field of bilharziasis.

Annex 1

LIST OF PARTICIPANTS

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Dr P. Clément, WHO Regional Office for Africa

Dr M. Sédeuihl, WHO Regional Office for Africa

Annex 2

DOCUMENTS SUBMITTED TO THE CONFERENCE *

WHO/Bil.Conf./1 — Bil.Ecol./3	African bilharzia vector snails, by G. Mandahl-Barth
WHO/Bil.Conf./2 — Bil.Ecol./7	Facilities for training malacologists and medical zoologists in the University of Michigan, by H. van der Schalie
WHO/Bil.Conf./3	The nature of the "schistosome-vector" complex in Brazil and its relation to the epidemiology and prophylaxis of intestinal bilharziasis in South America, by Alice Buttner
WHO/Bil.Conf./4 — Bil.Ecol./16	Snail vector control in the bilharziasis project at Qaliub, Egypt, by H. van der Schalie
WHO/Bil.Conf./5 — Bil.Ecol./18	Distribution of the intermediate hosts of bilharziasis in relation to hydrography, with special reference to the Nile Basin and the Sudan, by E. T. Abdel Malek
WHO/Bil.Conf./6	The snail vectors in Southern Rhodesia, by W. Alves
WHO/Bil.Conf./7	Observations on the bilharzia complement-fixation test in schoolchildren after successful treatment, by Botha de Meillon & E. A. Hollingham
WHO/Bil.Conf./8	The relationship of bilharziasis to cancer in South Africa, by J. Higginson
WHO/Bil.Conf./9	Comments on the epidemiology and control of bilharziasis, by D. B. McMullen & H. W. Harry
WHO/Bil.Conf./10	Survey methods in South Africa, by R. J. Pitchford
WHO/Bil.Conf./11	Animal reservoirs of human bilharziasis in the Eastern Transvaal, by R. J. Pitchford
WHO/Bil.Conf./12	Studies on immunity to schistosomiasis mansoni. I. Evaluation of the circumoval precipitin test as a diagnostic procedure in clinical schistosomiasis mansoni. Report of 46 cases, by R. Rodríguez-Molina, J. Oliver-González & D. G. Serrano
WHO/Bil.Conf./13	Field trials of various molluscicides (chiefly sodium pentachlorophenate) for the control of aquatic intermediate hosts of human bilharzia, by W. H. Wright, C. G. Dobrovolny & E. G. Berry
WHO/Bil.Conf./14	The "schistosome-vector" complex according to the geographic strain of the parasites and vectors, by B. Hubendick
WHO/Bil.Conf./15	Host parasite relationship in some Brazilian *Planorbidae* infected with *Schistosoma mansoni*, by F. S. Barbosa
WHO/Bil.Conf./16	Influence of human concentration and the activity of various social groups in the community on the incidence of bilharziasis, by J. M. Watson

* Some of these papers will be published in 1958 in the *Bulletin of the World Health Organization*.

WHO/Bil.Conf./17	The value of mass treatment in South Africa, by R. J. Pitchford
WHO/Bil.Conf./18 — Bil.Ecol./20	Effect of extension of irrigation and agriculture on the incidence of bilharziasis, by J. M. Watson
WHO/Bil.Conf./19 — Bil.Ecol./21	Quantitative methods of measuring density of populations of molluscs, by J. M. Watson
WHO/Bil.Conf./20 — Bil.Ecol./22	Relationship between control methods and the ecology and biology of the snail vectors of bilharziasis, by J. M. Watson
WHO/Bil.Conf./21	Studies on bilharziasis japonica in the Philippines. I. Baseline data, fundamental investigations and preliminary control experiments, by T. P. Pesigan, M. Farooq, N. G. Hairston, J. J. Jáuregui, E. C. García, A. T. Santos, B. C. Santos & A. A. Besa
WHO/Bil.Conf./22 — Bil.Ecol./27	Survival of pulmonate bilharzia vectors out of water, by L. J. Olivier
WHO/Bil.Conf./23	Influence of living conditions of Africans on the incidence of bilharziasis in the Transvaal, by R. J. Pitchford
WHO/Bil.Conf./24	The intradermal test in the diagnosis of bilharziasis, by J. Pellegrino
WHO/Bil.Conf./25	Lucanthone hydrochloride : a review, by D. M. Blair
WHO/Bil.Conf./26	Non-human vertebrate hosts of *Schistosoma haematobium* and *Schistosoma mansoni*, by A. Vianna Martins
WHO/Bil.Conf./27	A review of the present status of bilharziasis control by application of molluscicides, by E. Paulini
WHO/Bil.Conf./28	Studies bearing on parasitism and nutritional state, by A. R. P. Walker
WHO/Bil.Conf./29	The deposition of bilharzia eggs in the tissues, by W. Alves
WHO/Bil.Conf./30 — Bil.Ecol./29	The snails in the collection of the WHO Snail Identification Centre, Salisbury, Southern Rhodesia, by W. Alves
WHO/Bil.Conf./31 & Add.1 — Bil.Ecol./30 & Add.1	Relation between irrigation engineering and bilharziasis, by J. N. Lanoix
WHO/Bil.Conf./32	A note on immunity, by W. Alves
WHO/Bil.Conf./33	The " miracidiascope " in bilharziasis, by W. Alves
WHO/Bil.Conf./34	*Planorbis*, *Bulinus* and *Lymnaca* in Madagascar, by G. Ranson
WHO/Bil.Conf./35	The present position in Southern Rhodesia, by W. Alves
WHO/Bil.Conf./36	Antimony dimercaptosuccinate (TWSb) in the treatment of urinary bilharziasis, by H. H. Salem, A. T. El Cherif & E. A. H. Friedheim
WHO/Bil.Conf./37	Bilharziasis survey in Basutoland (March 1956), by R. J. Pitchford
WHO/Bil.Conf./38	Bilharziasis survey in Bechuanaland (March 1956), by R. J. Pitchford
WHO/Bil.Conf./39	Bilharziasis survey in Swaziland (March 1956), by R. J. Pitchford

WHO/Bil.Conf./40	The importance of morbidity due to bilharziasis and possible methods for its quantitative assessment, by T. H. Davey & R. M. Gordon
WHO/Bil.Conf./41	Bilharziasis in French West Africa, by J. Gillet
WHO/Bil.Conf./42	Bilharziasis in Angola, by J. Gillet
WHO/Bil.Conf./43	Human bilharziasis in the Gold Coast, by J. Gillet
WHO/Bil.Conf./44	Bilharziasis in Portuguese Guinea, by J. Gillet
WHO/Bil.Conf./45	Further studies in the treatment of urinary bilharziasis with lucanthone hydrochloride, by W. Alves
WHO/Bil.Conf./46	Role played in bilharziasis epidemiology by human geography and by social activities of the various groups in a community, by J. Gaud
*WHO/Bil.Conf./47	Rapport sur les bilharzioses humaines au Maroc Espagnol, by J. Fraga de Azevedo
*WHO/Bil.Conf./48	Rapport sur les bilharzioses humaines en Afrique Equatoriale Française, by J. Fraga de Azevedo
*WHO/Bil.Conf./49	Rapport sur les bilharzioses humaines au Cameroun Français, by J. Fraga de Azevedo
WHO/Bil.Conf./50	Report on human bilharziasis in the British Cameroons, by J. Fraga de Azevedo
WHO/Bil.Conf./51	Bilharziasis surveys in Africa (1950-1956), by WHO Consultants
WHO/Bil.Conf./52	Distribution of the provable or potential vectors of human bilharziasis south of the Sahara, by G. Mandahl-Barth
WHO/Bil.Conf./53	Provisional agenda
WHO/Bil.Conf./54	List of documents
*WHO/Bil.Conf./55 & Add.1	Observations sur la répartition géographique de trois planorbes africains, by G. Ranson
WHO/Bil.Conf./56	Acquired resistance to schistosoma infection in experimental animals, by H. Vogel
*WHO/Bil.Conf./57	Problèmes actuels de la bilharziose ; quelques suggestions pour son étude, by J. Fraga de Azevedo
*WHO/Bil.Conf./58	Observations sur la répartition géographique de quelques espèces de planorbes du genre *Biomphalaria*, de l'Afrique du Sud au lac Albert, by G. Ranson
WHO/Bil.Conf./59	Fundamental elements for the study of bilharziasis in Angola, by G. Jorge Janz & A. Morais de Carvalho
WHO/Bil.Conf./60	Present state of the bilharziasis problem in the Portuguese territories in Africa, by J. Fraga de Azevedo
*WHO/Bil.Conf./61	Observations sur la répartition géographique de trois espèces de planorbes africains de genre *Biomphalaria*, by G. Ranson
WHO/Bil.Conf./62	Immunity in bilharziasis, by Botha de Meillon

* In French only

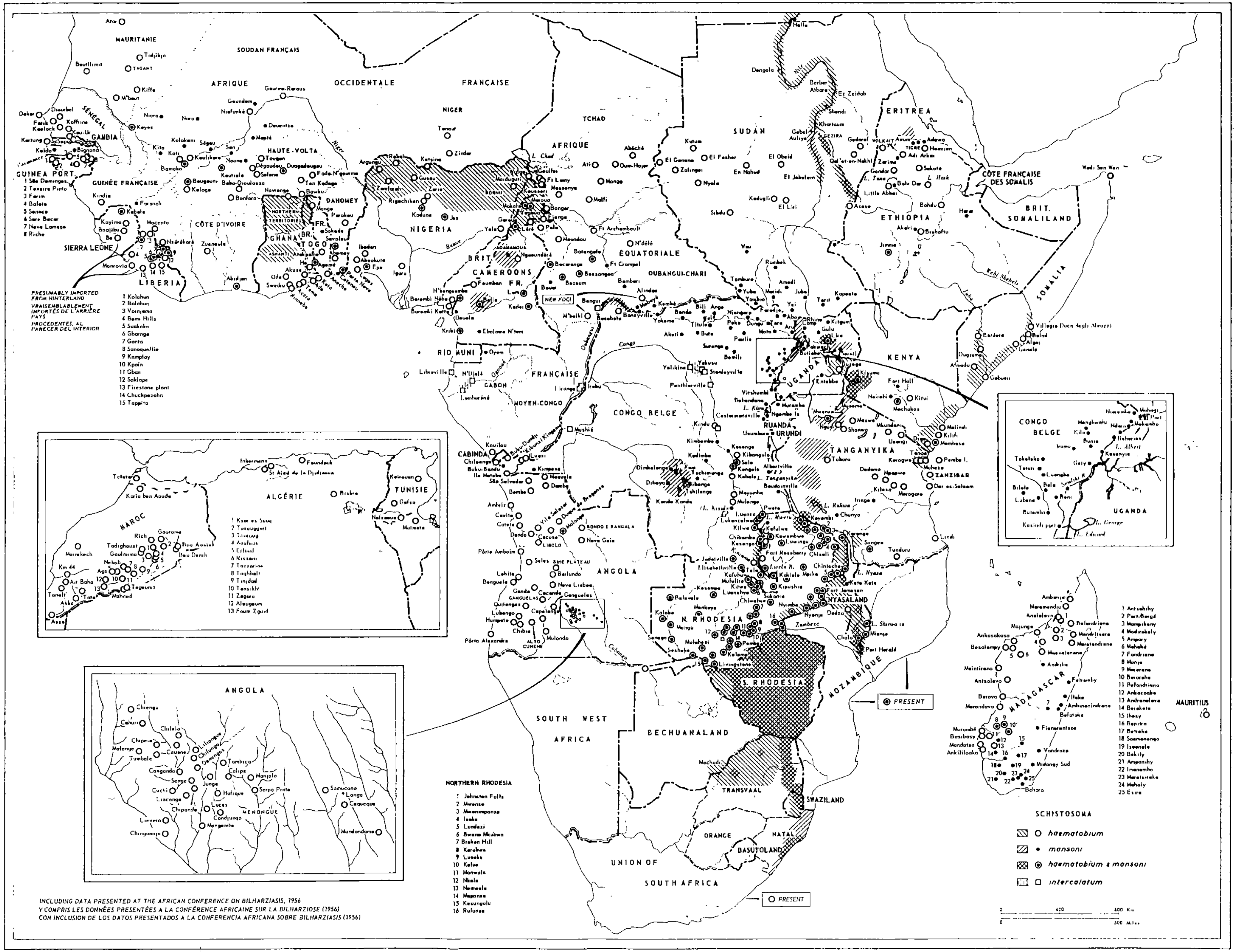
Annex 3

SUSCEPTIBILITY OF CERTAIN AFRICAN AND EUROPEAN STRAINS OF LABORATORY-BRED PLANORBINAE AND BULININAE TO CERTAIN STRAINS OF AFRICAN MAMMALIAN SCHISTOSOMES

Species of snails	Origin	Species of mammalian schistosomes											
		S. haematobium Egyptian strain	*S. haematobium* Rhodesian strains	*S. mattheei* Belgian Congo strain	*S. mattheei* Rhodesian strains	*S. mattheei* Transvaal strain	*S. intercalatum* Belgian Congo strain	*S. rodhaini* Albertville strain	*S. rodhaini* Elizabethville strain	*S. mansoni* Cairo strain	*S. mansoni* Kenya strain	*S. mansoni* Nigeria strain	*S. mansoni* var. *rodentorum* Albertville strain
Bulinus (B.) truncatus	Egypt	+++	—	—	—	—	—	0	0	0	0	0	0
	Sardinia	+++	—	—	—	—	—	0	0	0	0	0	0
Bulinus (B.) coulboisi	Belgian Congo	+++	—	—	—	—	—	0	0	0	0	0	0
Bulinus (B.) forskalii	Gambia	+++	—	0	—	0	0	0	0	0	0	0	0
Bulinus (B.) tropicus	Northern Rhodesia	—	—	—	—	—	—	—	—	—	—	—	—
	Southern Rhodesia	—	—	—	—	—	—	0	0	0	0	0	0
Bulinus (Ph.) africanus	Durban	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
	Northern Rhodesia	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
	Southern Rhodesia	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
Bulinus (Ph.) globosus	Belgian Congo	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
	Northern Rhodesia	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
	Southern Rhodesia	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
	Transvaal	—	+++	+++	+++	+++	+++	0	0	0	0	0	0
Bulinus (Ph.) ugandae	Uganda	—	—	—	—	—	—	0	0	0	0	0	0
Biomphalaria alexandrina	Egypt	0	0	0	0	0	0	—	—	+++	+	+	—
Biomphalaria pf. pfeifferi	Natal	0	0	0	0	0	0	—	—	—	—	—	—
Biomphalaria pf. bridouxiana	Belgian Congo	0	0	0	0	0	0	+++	+++	+++	+++	+++	+++
Biomphalaria rüppellii	Kisumu	0	0	0	0	0	0	—	—	—	+++	+++	+
Biomphalaria sudanica tanganyicensis	Albertville	0	0	0	0	0	0	—	—	—	+	0	+++
Lymnaea natalensis	Southern Rhodesia	—	—	0	—	0	0	0	0	0	0	0	0
Lymnaea acuminata var. *rufescens*	India	—	—	0	—	0	—	0	0	0	0	0	0
Planorbarius metidjensis	Portugal	—	—	—	—	—	—	—	—	—	—	—	—
Planorbarius corneus	England	—	—	0	—	0	0	—	—	—	—	—	—
Indoplanorbis exustus	India	—	—	0	—	0	0	—	—	—	—	—	—

+++ = highly susceptible + = poor susceptibility — = not susceptible 0 = not tested

DISTRIBUTION OF HUMAN BILHARZIASIS IN AFRICA



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No. 139 **African Conference on Bilharziasis,** Brazzaville, French Equatorial Africa, 26 November-8 December 1956 Report	1/9	0.30	1.—
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